

APPENDIX B
RESPONSE CHARTS

B.1 INTRODUCTION

The response charts presented in this appendix were prepared as a design aid alternative to the use of equations in Chapter 5. They should only be used for preliminary design or analysis. The charts are plots of Eq. 5-54 for a range of values of B/R_m or P_r/r_m (the load term "B" and the resistance term " R_m " as shown on the charts may be either total load and total resistance (B/R_m) or unit load and unit resistance (P_r/r_m)), t_1/T_N , C_1 , C_2 and the ductility ratio μ , where

- B = peak total load, pounds
- P_r = peak unit pressure, psi
- R_m = maximum resistance of structural element, pounds
- r_m = maximum unit resistance of structural element, psi
- t_1 = duration of reflected pressure pulse, sec
- T_N = fundamental period of vibration of element, sec
- $C_1 = (P_r - P_{qs})/P_r$
- $C_2 = P_{qs}/P_r$
- P_{qs} = peak quasi-static pressure, psi
- $\mu = X_m/X_e$ = ductility ratio
- X_m = maximum displacement of single degree of freedom system, in
- X_e = yield displacement of single degree of freedom system, in

The chart solutions are based upon the same assumptions stated for Eq. 5-54, i.e.,

- A short duration impulsive load superimposed on a long duration quasi-static loading.
- An elastic-plastic resistance function for the structural element.
- No structural damping in system.

Since they are derived for an infinite duration quasi-static pressure, the charts yield conservative results for a decaying quasi-static pressure component. The degree of conservatism depends on the actual pulse duration. For cases where the duration of the reflected pressure is of the same order of magnitude as the period of the structure, the charts of this appendix will yield unconservative results and the charts should not be extrapolated beyond the values plotted. The charts can always be used, however, for initial selection of a trial section for further analysis.

B.2 USE OF CHARTS

The charts of this appendix can be used in various ways.

Class 1 - Find the maximum response of a given structural element to a specified loading function.

Class 2 - Find the required maximum resistance for a given loading and specified maximum response.

Class 3 - Find the maximum allowable peak pressure for a given structural element and specified maximum response.

Except for the first class of problems where the loading function and structural properties are specified, an iterative process is required to obtain a solution. For the first class of problems, one must compute C_1 , C_2 , B/R_m and t_1/T_N . Next, locate the appropriate chart for the computed values of C_1 and C_2 . On this chart, locate the curved line for the computed value of B/R_m . At the intersection of this curve with the vertical line representing the computed value t_1/T_N , read the ductility ratio μ on the vertical scale at the left side of the chart.

For the second class of problems, it is necessary to assume a trial section or a period of vibration. Then C_1 , C_2 and t_1/T_N are computed as before. Select the appropriate chart for the computed values of C_1 and C_2 . At the intersection of the vertical line representing the computed value of t_1/T_N and the horizontal line representing the specified ductility ratio μ , read the value B/R_m . From this ratio, compute the required R_m , select or design the element, and then recompute its period of vibration. If the new period differs significantly from the first value, the entire process must be repeated with a new value of t_1/T_N . Repeat the iterations until satisfactory agreement is achieved.

The last class of problems is perhaps the most difficult because of the greater number of parameters describing the loading function. The characteristics of the loading function must be assumed and the parameters C_1 , C_2 , t_1/T_N and B/R_m computed. The appropriate chart is selected and the maximum response (ductility ratio) determined. If the maximum response does not agree with that specified, a new loading function is assumed and the process repeated until the desired agreement is achieved.

Illustrative examples which demonstrate use of the response charts are presented below. These examples utilize given data from selected examples in Chapter V and, therefore, provide some comparison of the accuracy of the response charts for a range of problem parameters. As might be expected, where the problem parameters fit the criteria for use of Eq. 5-54, the agreement is good.

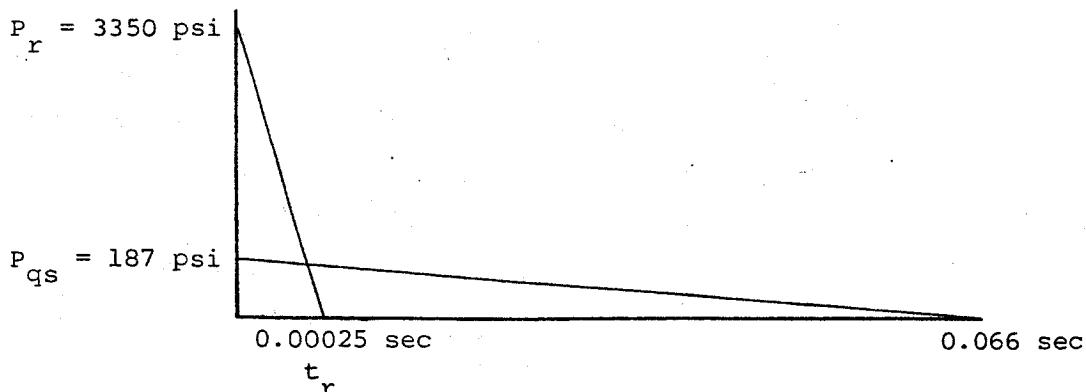
B.3 ILLUSTRATIVE EXAMPLES

B.3.1 Response of Group 3 Wall Beam Element to Airblast Loading

a. Given

From Example 5.6.1, a 48.8 pound charge of

Pentolite is detonated inside the Group 3 Suppressive Shield. The resulting airblast loading on the interior surfaces of the wall is shown below.



b. Find

The maximum response of beam elements in the shield wall using the response charts of Appendix B.

c. Solution

The following beam element properties were established in Ex. 5.6.1.

$$\text{Maximum resistance} = r_m = 236.13 \text{ psi}$$

$$\begin{aligned} \text{Fundamental period of vibration of beam elements} &= T_N \\ &= 0.00414 \text{ sec} \end{aligned}$$

From the given airblast loading function,

$$C_1 = \frac{P_r - P_{qs}}{P_r} = \frac{3350 - 187}{3350} = 0.944 \rightarrow \text{say } 0.94$$

$$C_2 = \frac{P_{qs}}{P_r} = \frac{187}{3350} = 0.056 \rightarrow \text{say } 0.06$$

$$t_r = t_1 = 0.00025 \text{ sec}$$

and

$$t_1/T_N = 0.00025/0.00414 = 0.0604$$

$$P_r/r_m \text{ (same as } B/R_m) = \frac{3350}{236.13} = 14.19$$

In order to use the response charts, it is necessary to assume an infinite duration for the quasi-static pressure rather than the load duration predicted by blow-down time computations.

From Fig. B-35 for $C_1 = 0.94$, $C_2 = 0.06$ with P_r/r_m (same as B/R_m) = 14.19 and $t_1/T_N = 0.0604$, the ductility ratio, $\mu \approx 24$.

Using Eq. 5-55 in Ex. 5.6.1, it was found that $\mu = 15$. The greater response obtained from using the charts is largely due to the assumption of an infinite duration load. For this example, the difference is

$$100 \frac{24-15}{15} = 57 \text{ percent increase in computed maximum response.}$$

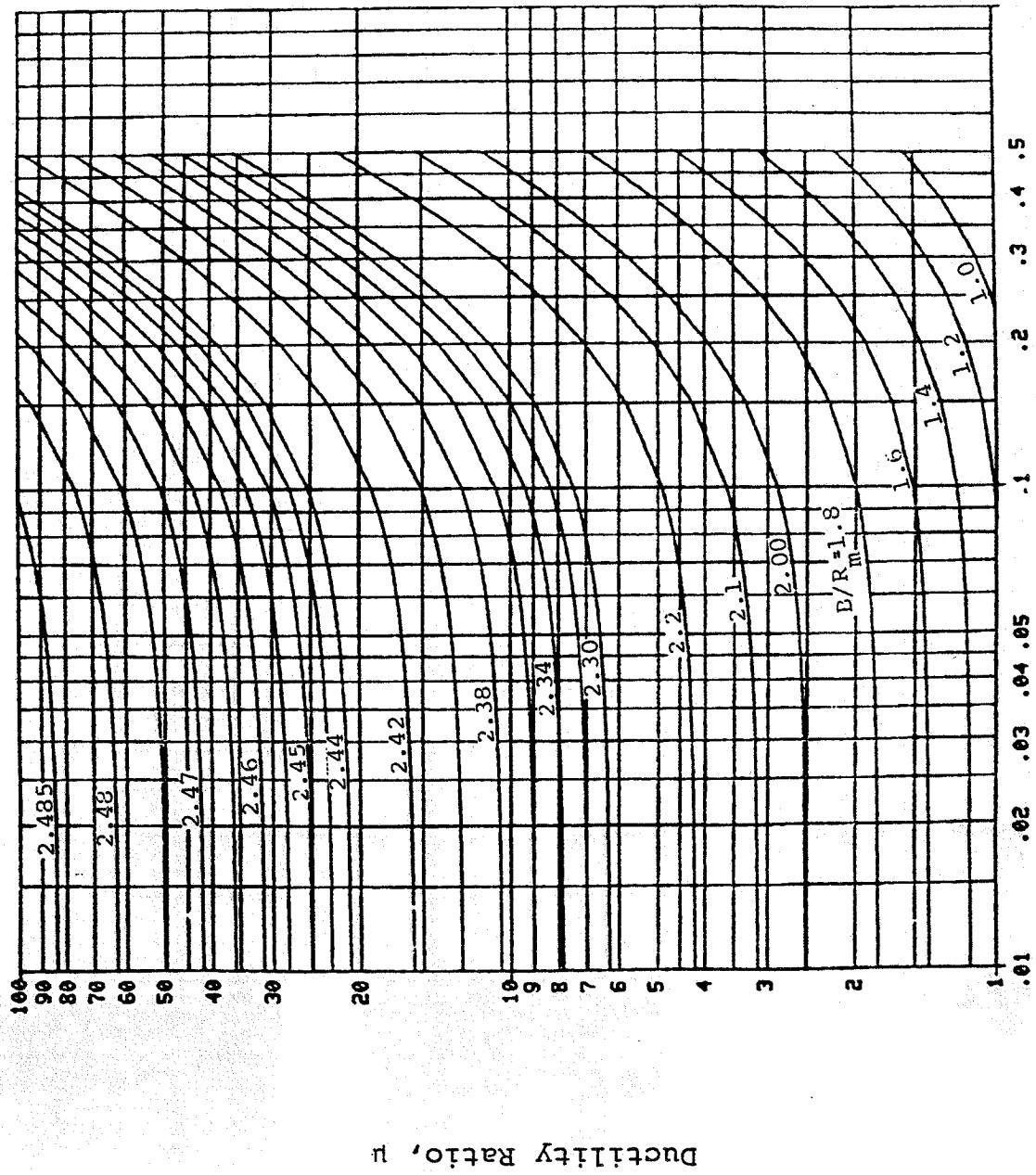


Figure B-1. Response Chart for $C_1 = 0.60$ and $C_2 = 0.40$

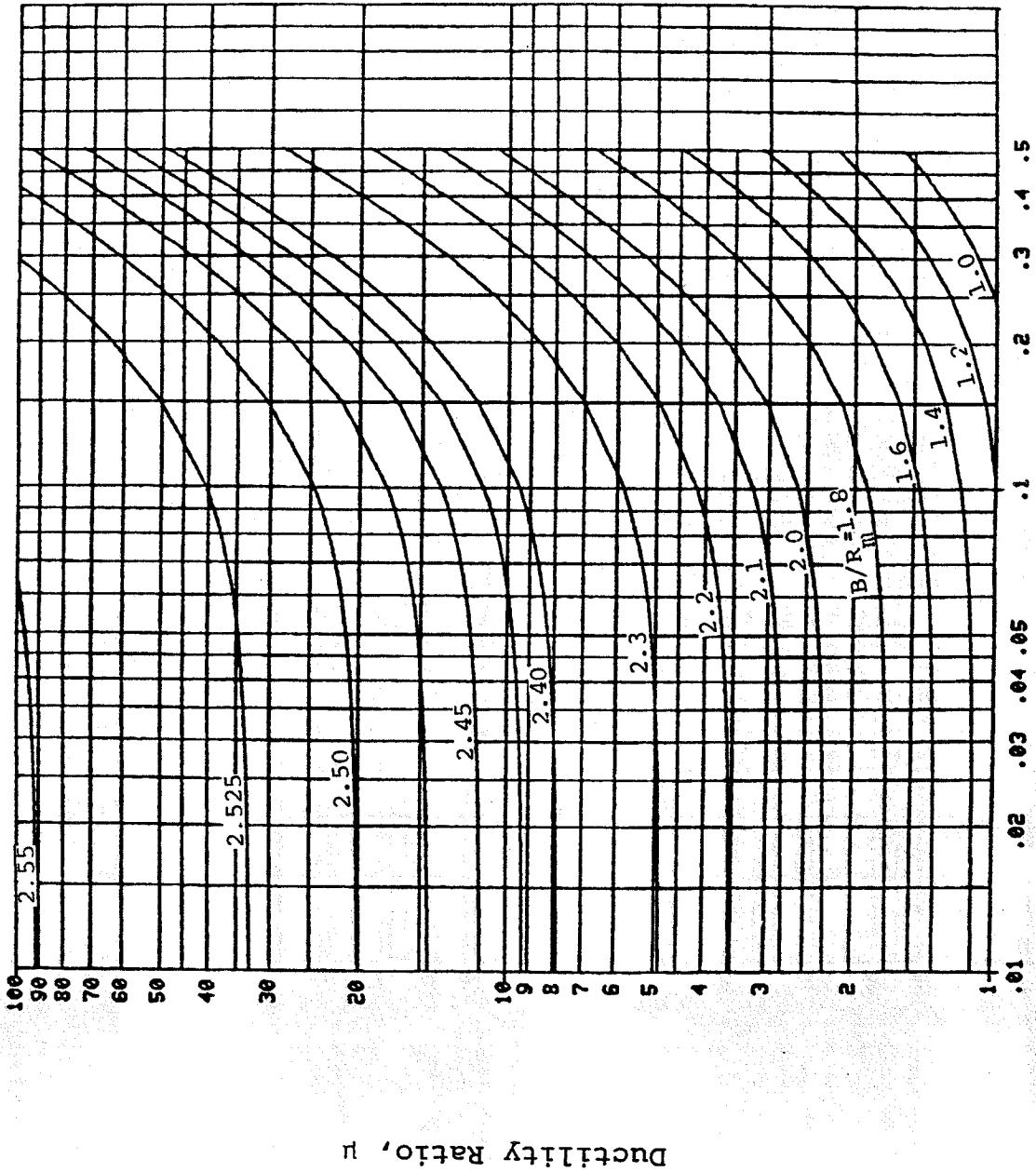
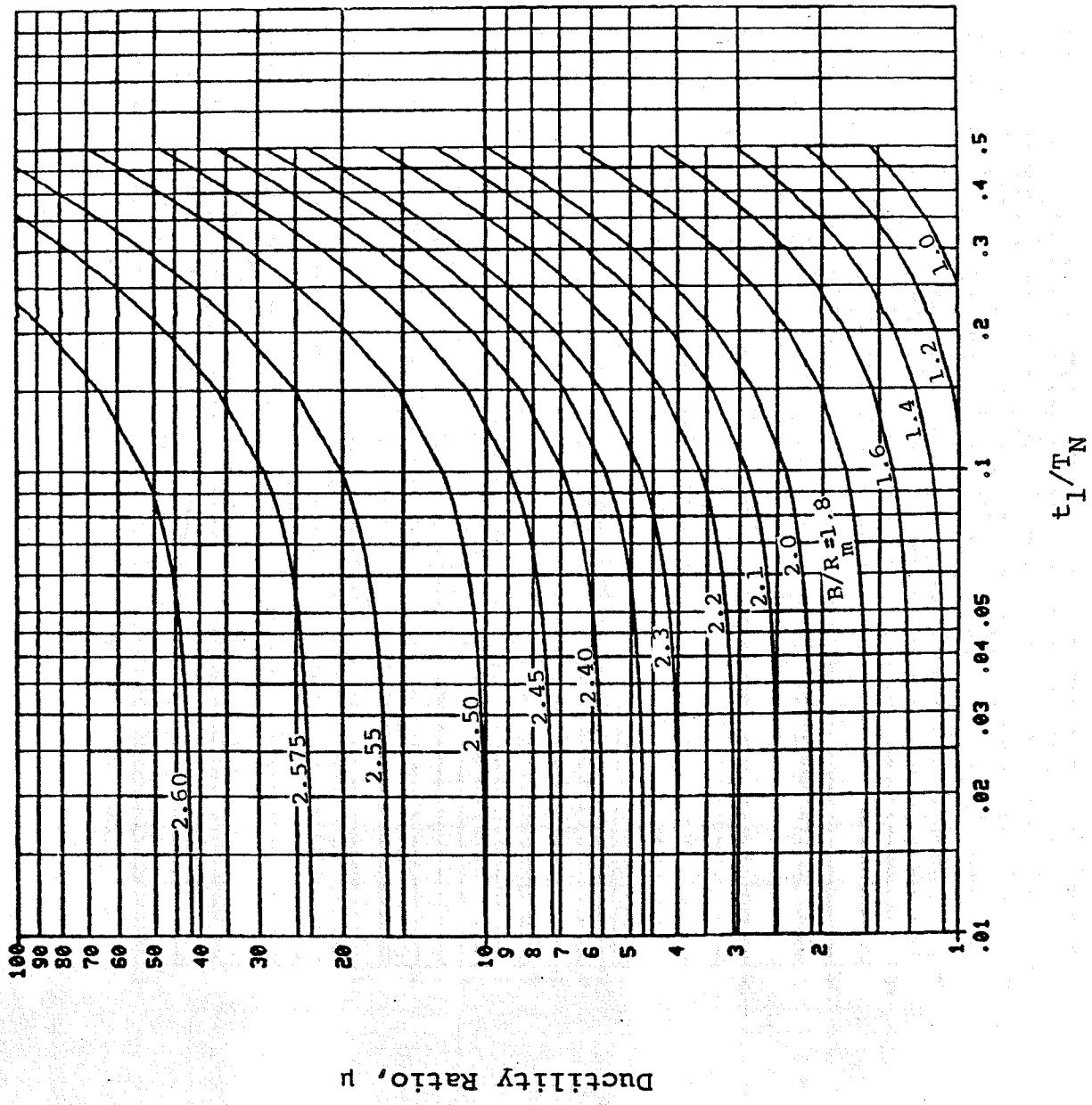
Ductility Ratio, μ

Figure B-2. Response Chart for $C_1 = 0.61$ and $C_2 = 0.39$

Ductility Ratio, μ t_1/T_N Figure B-3. Response Chart for $C_1 = 0.62$ and $C_2 = 0.38$

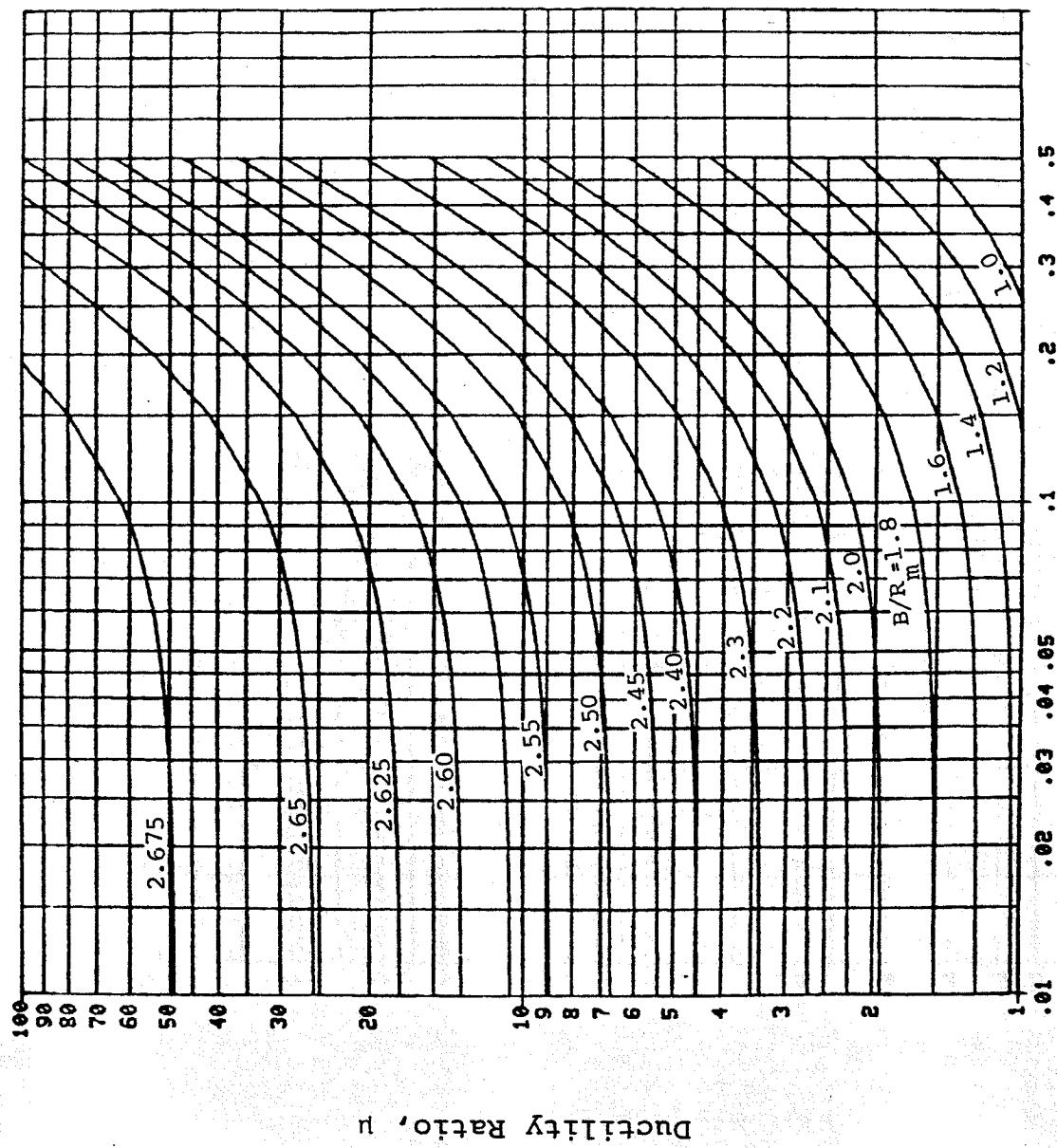
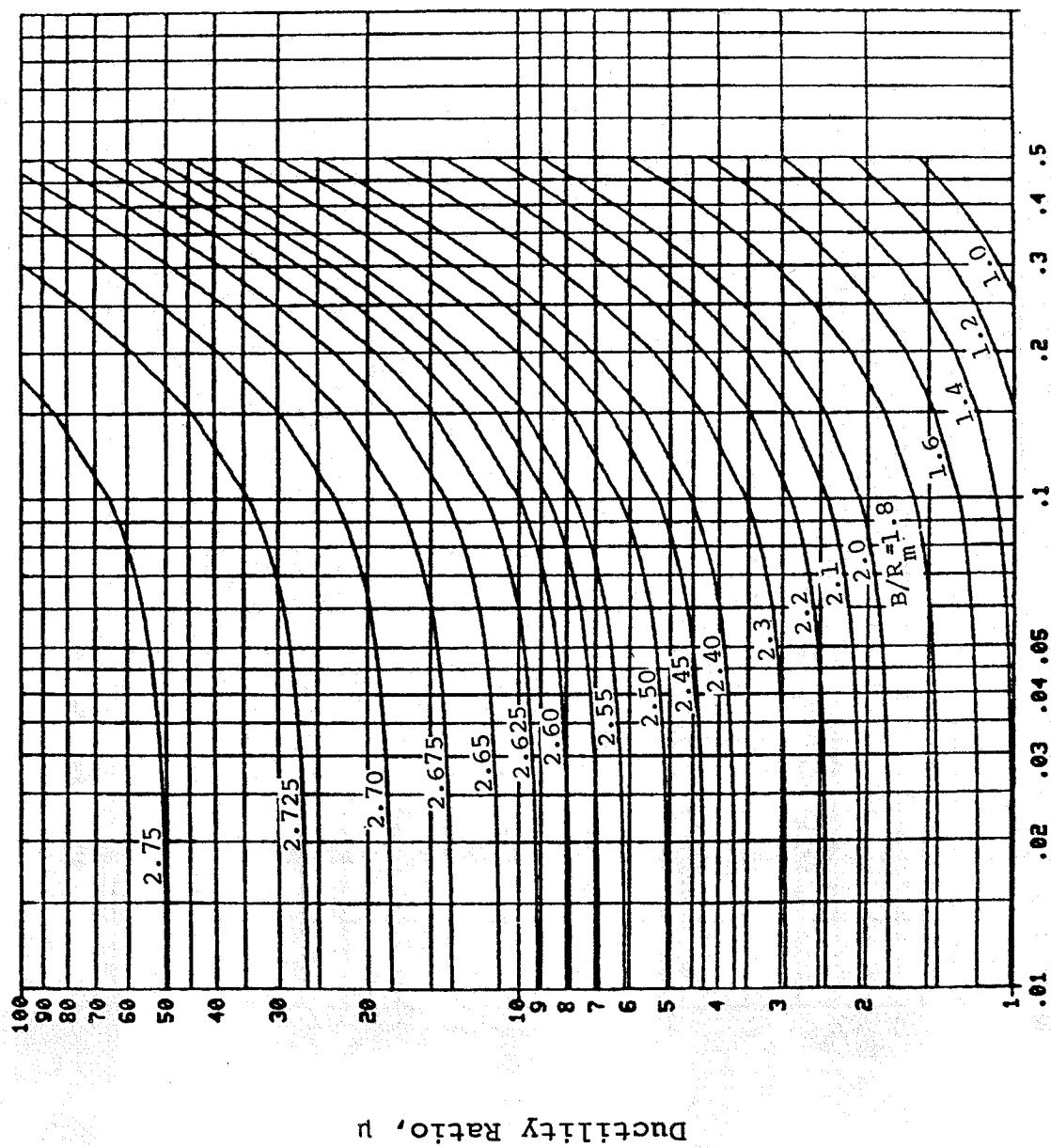


Figure B-4. Response Chart for $C_1 = 0.63$ and $C_2 = 0.37$

DUCTILITY RATIO, μ Figure B-5. Response Chart for $C_1 = 0.64$ and $C_2 = 0.32$

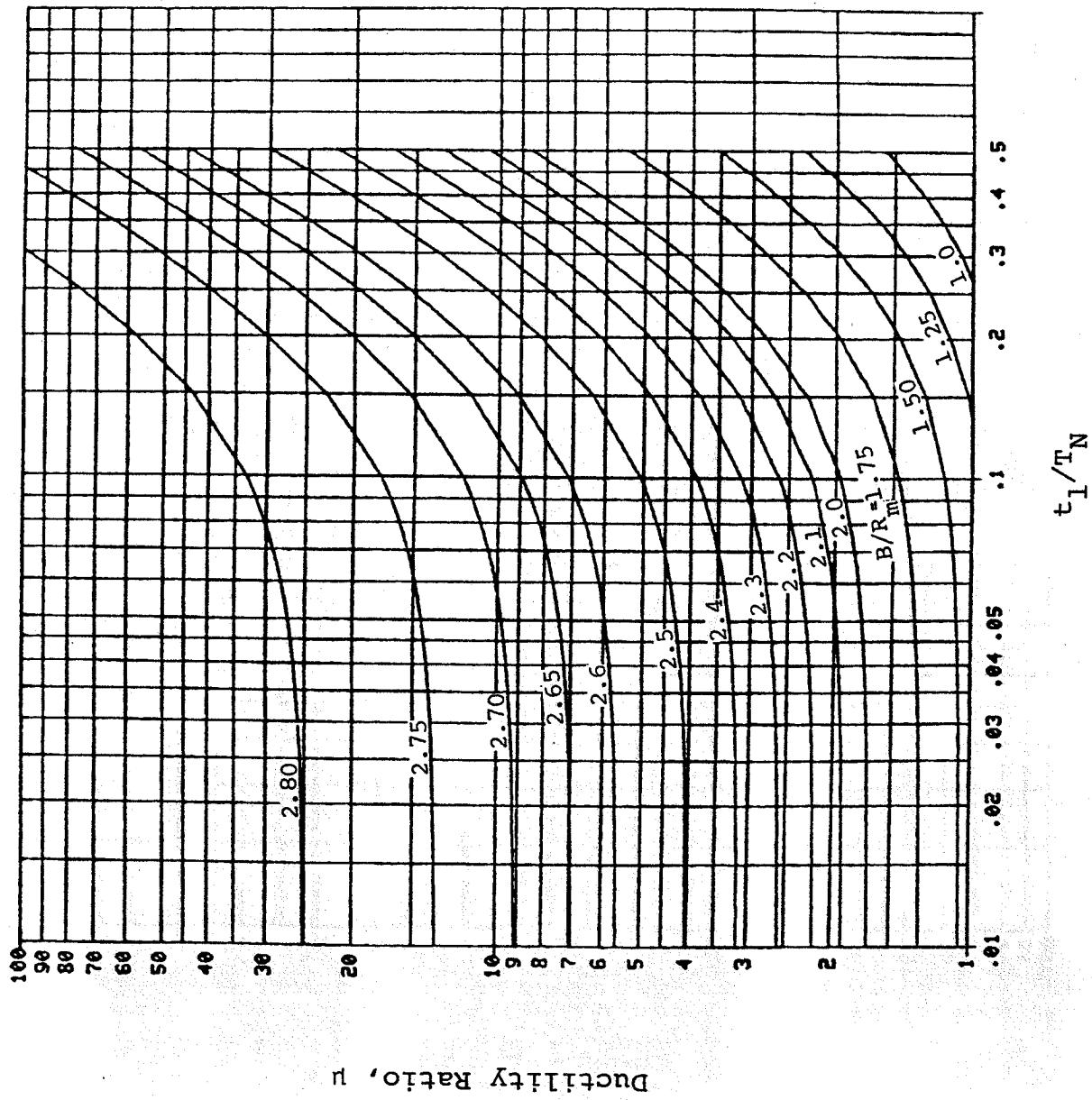


Figure B-6. Response Chart for $C_1 = 0.65$ and $C_2 = 0.35$

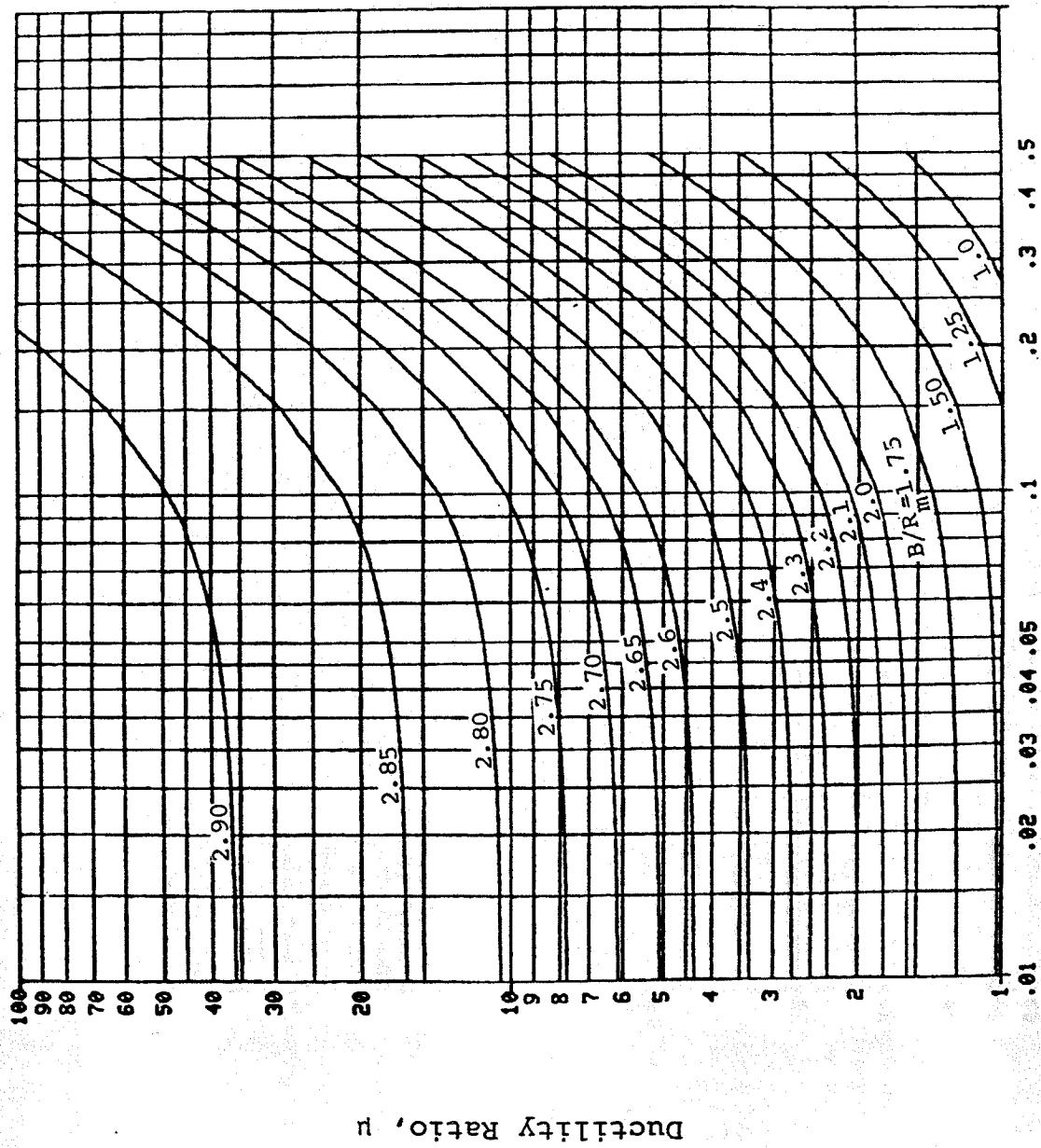
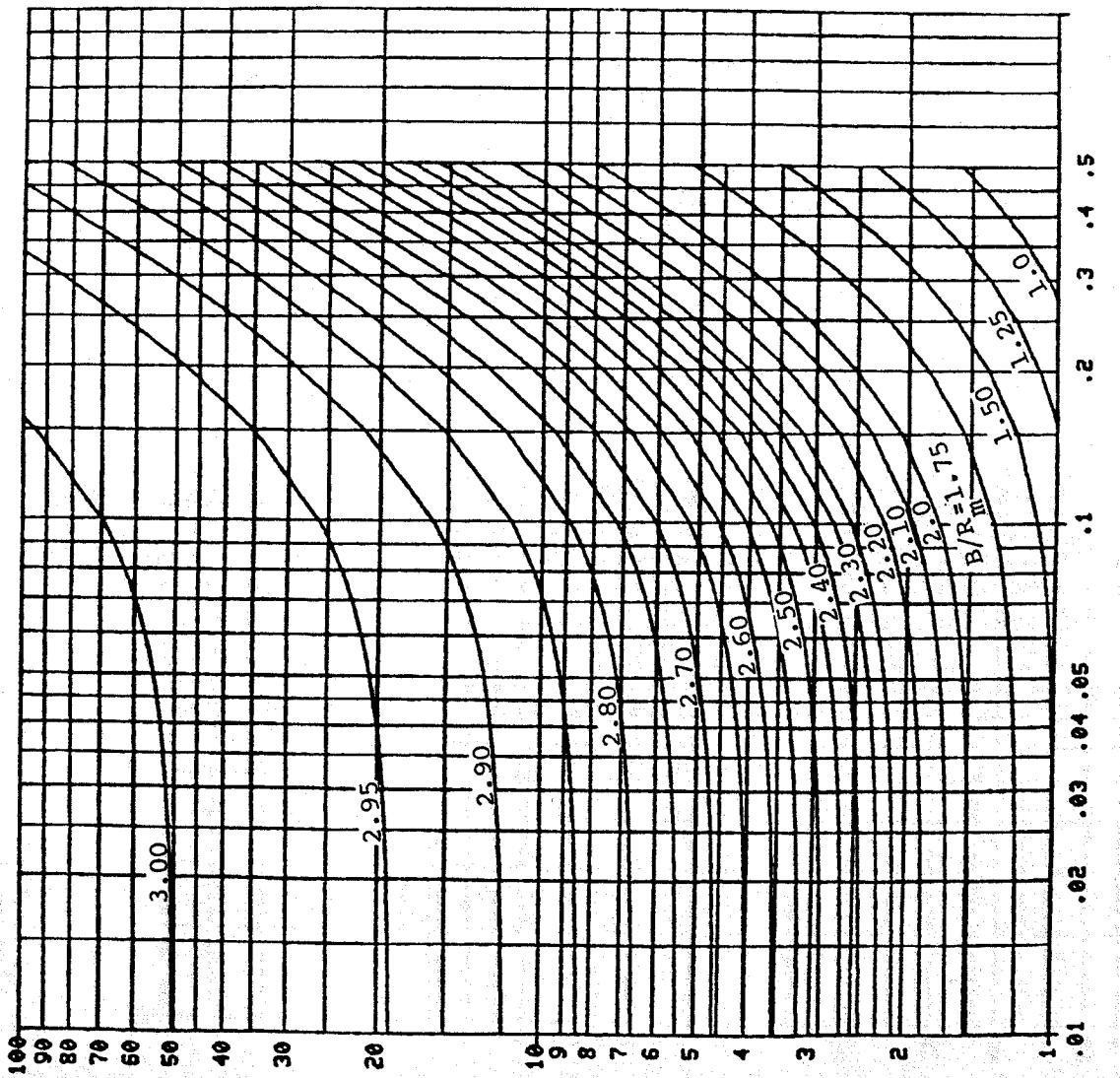


Figure B-7. Response Chart for $C_1 = 0.66$ and $C_2 = 0.34$

DUCTILITY RATIO, u Figure B-8. Response Chart for $C_1 = 0.67$ and $C_2 = 0.33$

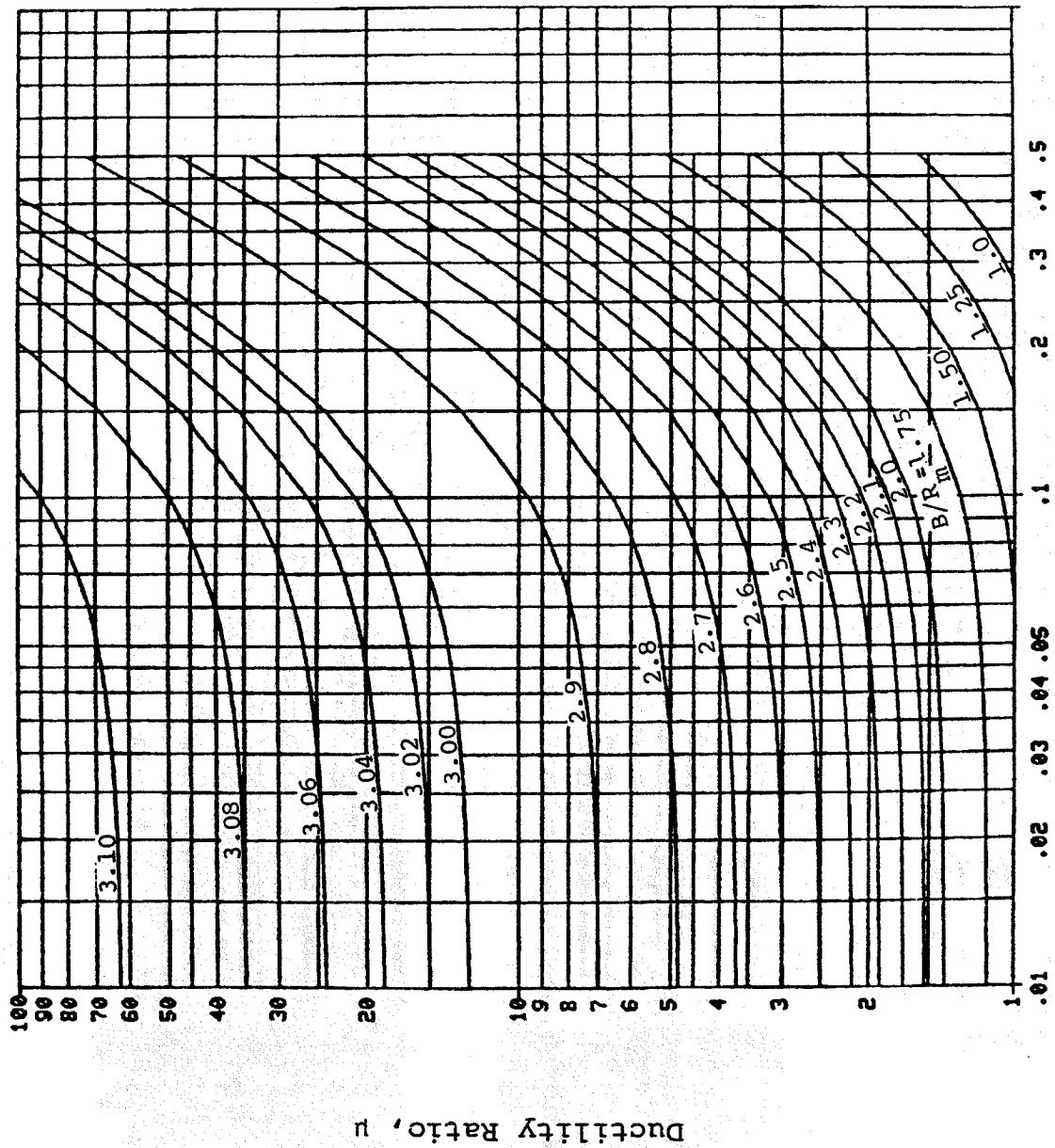
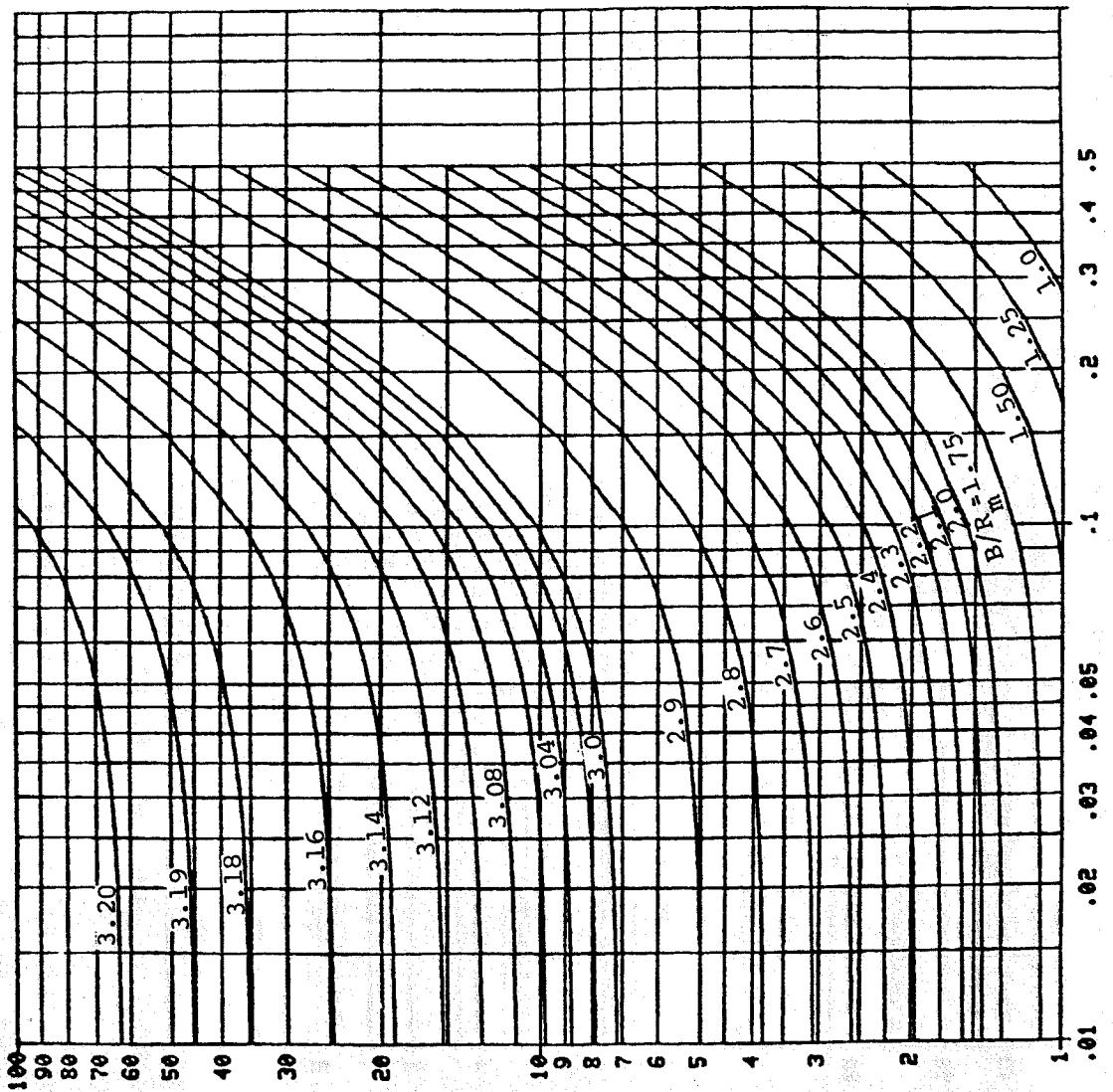
Ductility Ratio, μ

Figure B-9. Response Chart for $C_1 = 0.68$ and $C_2 = 0.32$

DUCTILITY RATIO, μ Figure B-10. Response Chart for $C_1 = 0.69$ and $C_2 = 0.31$

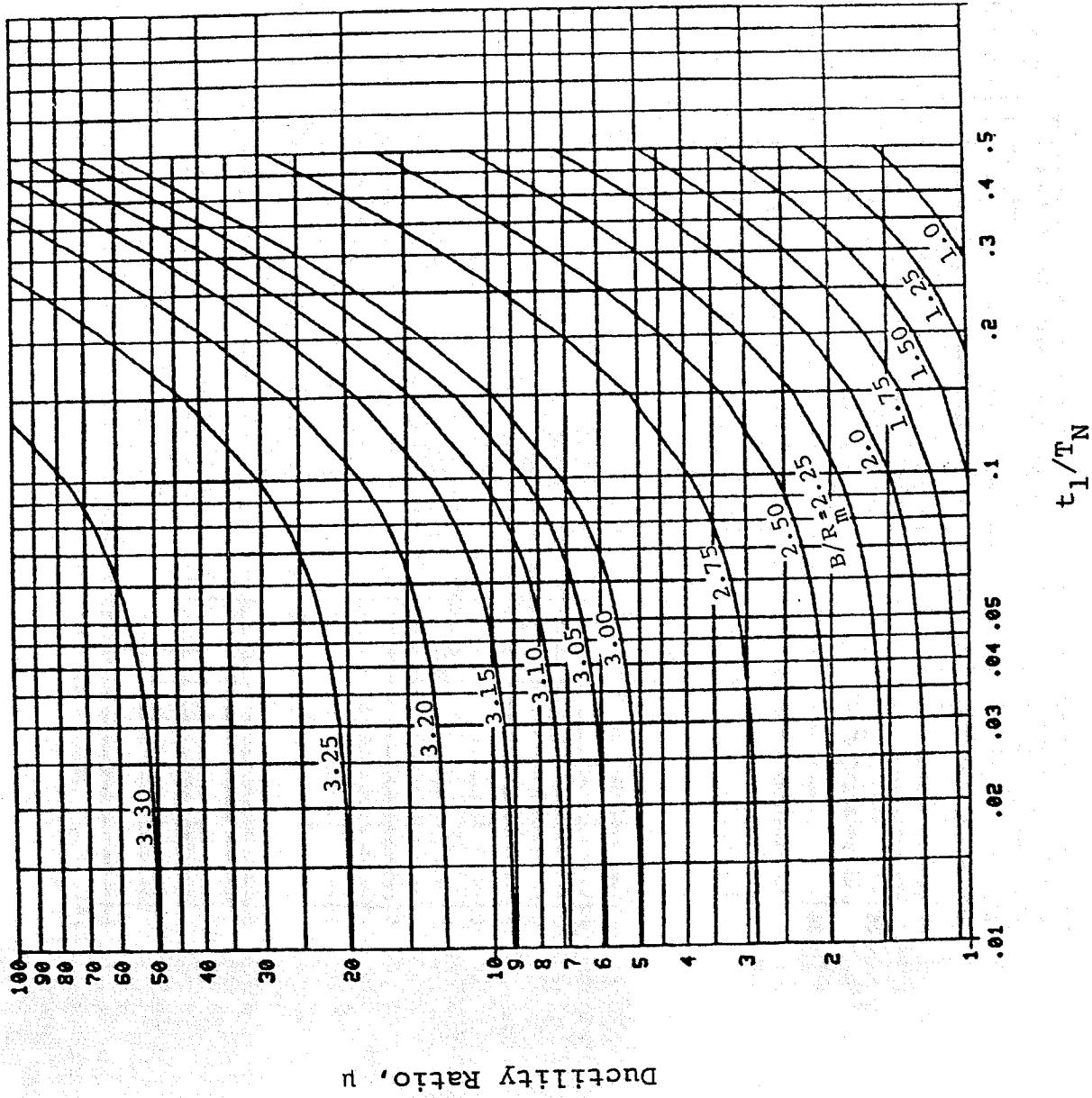


Figure B-11. Response Chart for $C_1 = 0.70$ and $C_2 = 0.30$

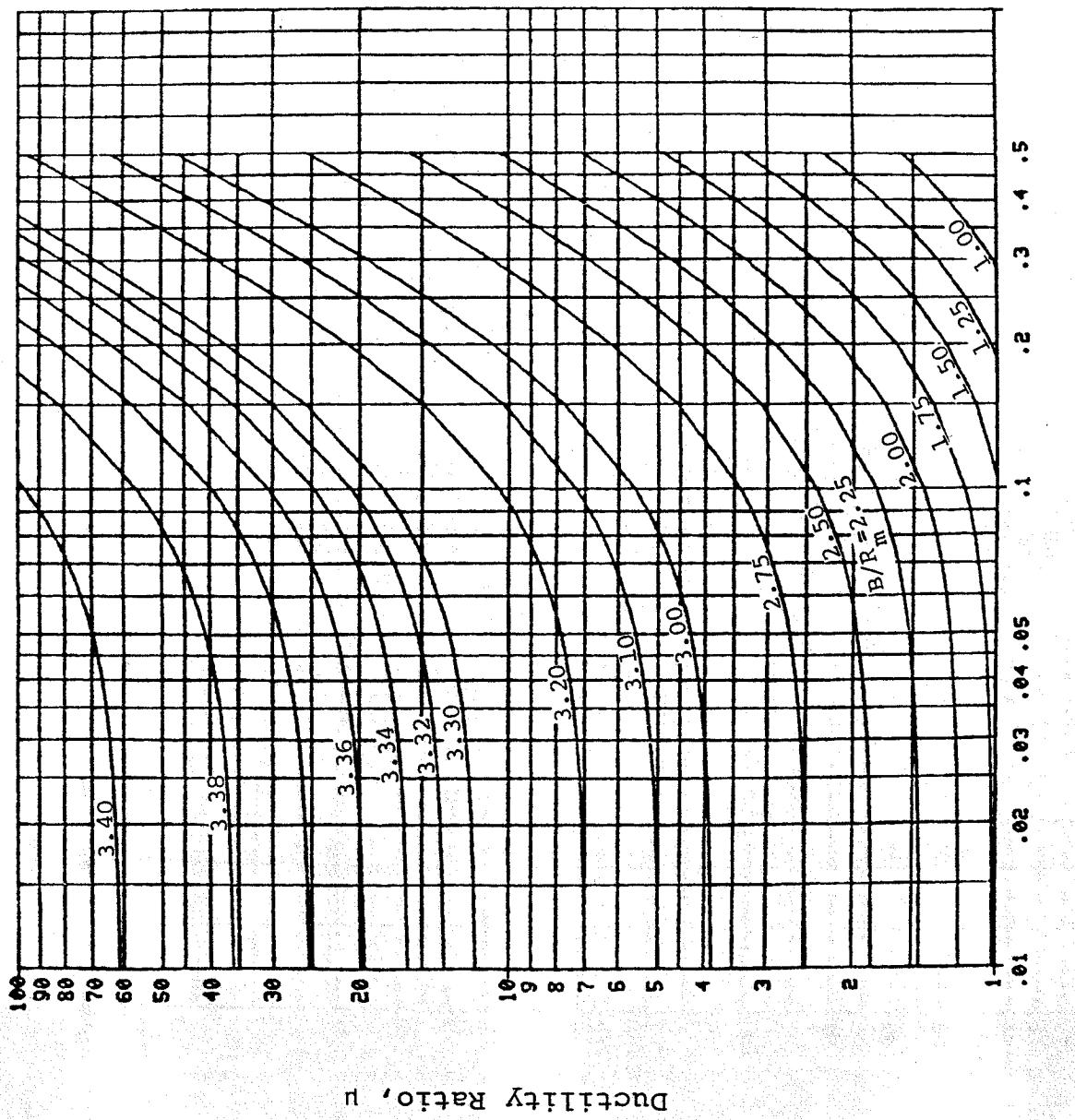


Figure B-12. Response Chart for $C_1 = 0.71$ and $C_2 = 0.29$

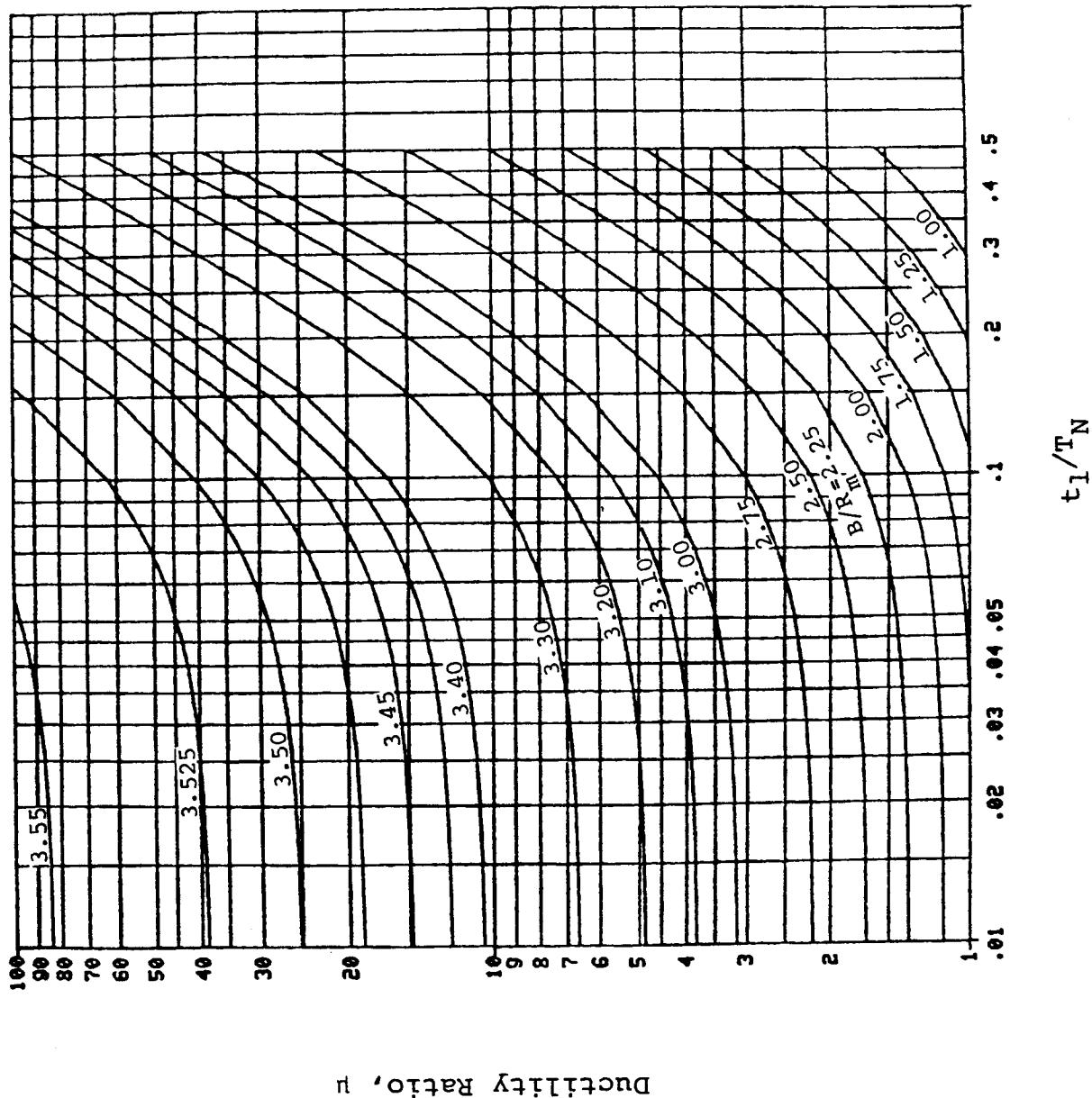


Figure B-13. Response Chart for $c_1 = 0.72$ and $c_2 = 0.28$

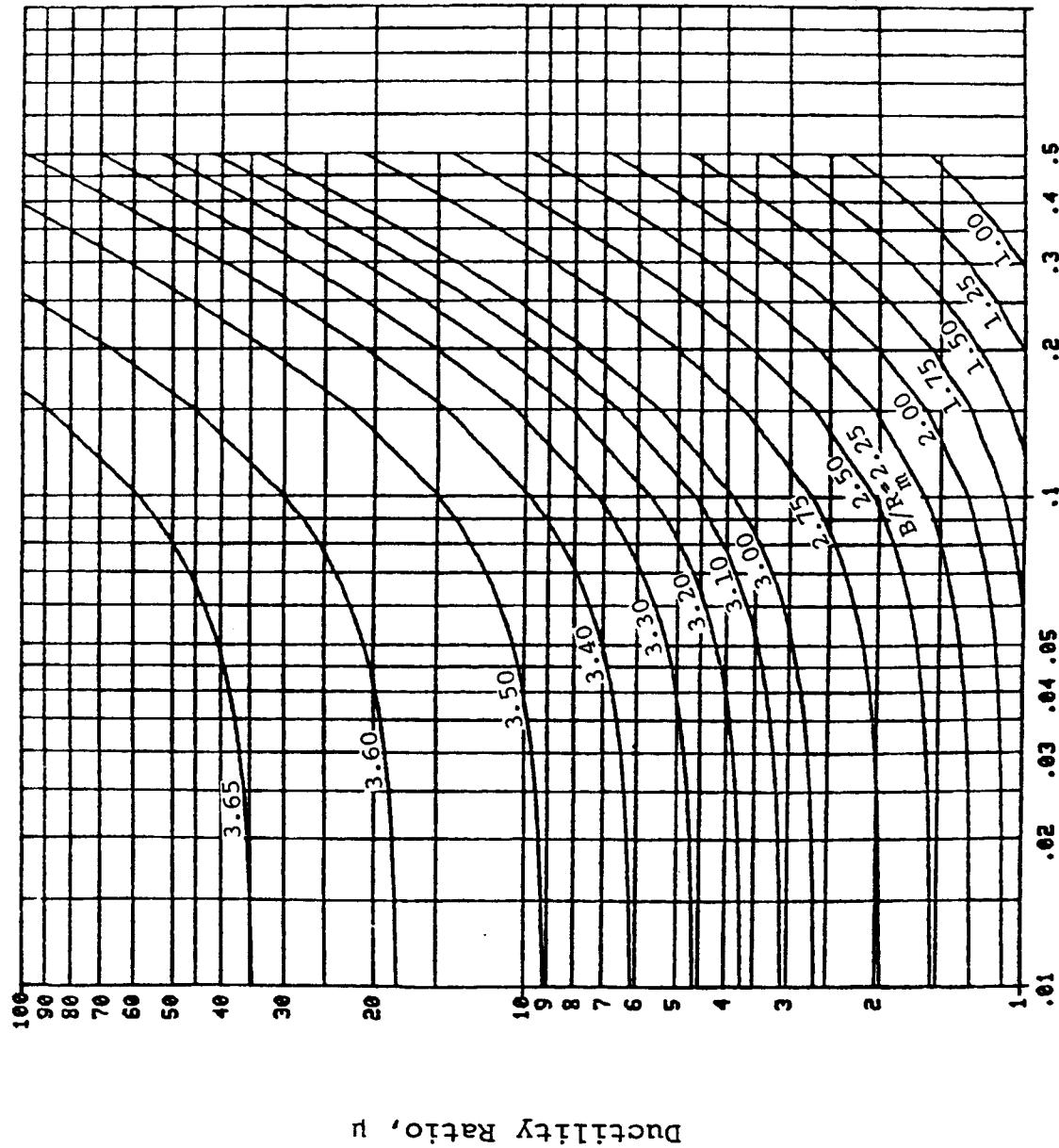


Figure B-14. Response Chart for $C_1 = 0.73$ and $C_2 = 0.27$

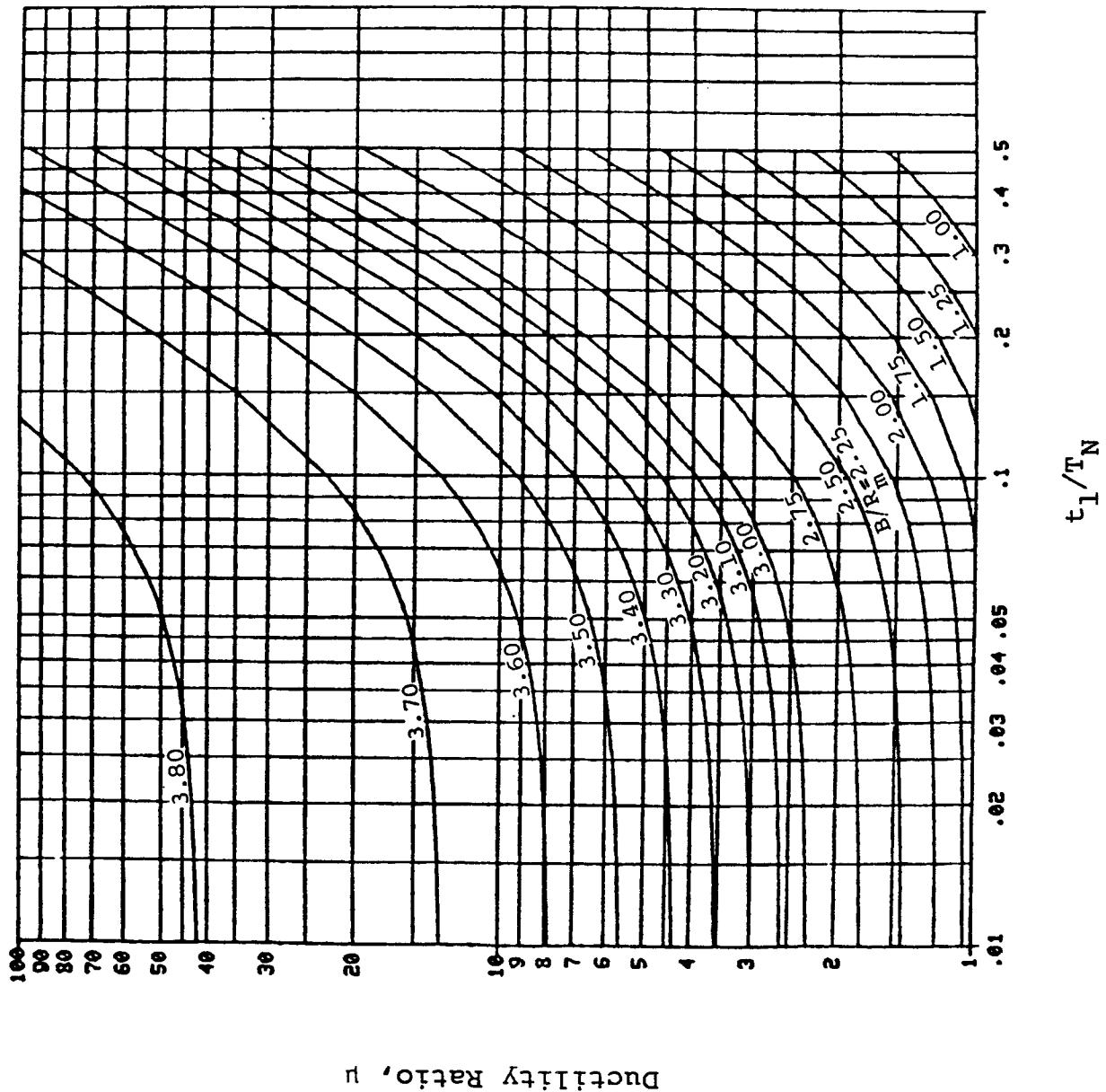


Figure B-15. Response Chart for $C_1 = 0.74$ and $C_2 = 0.26$

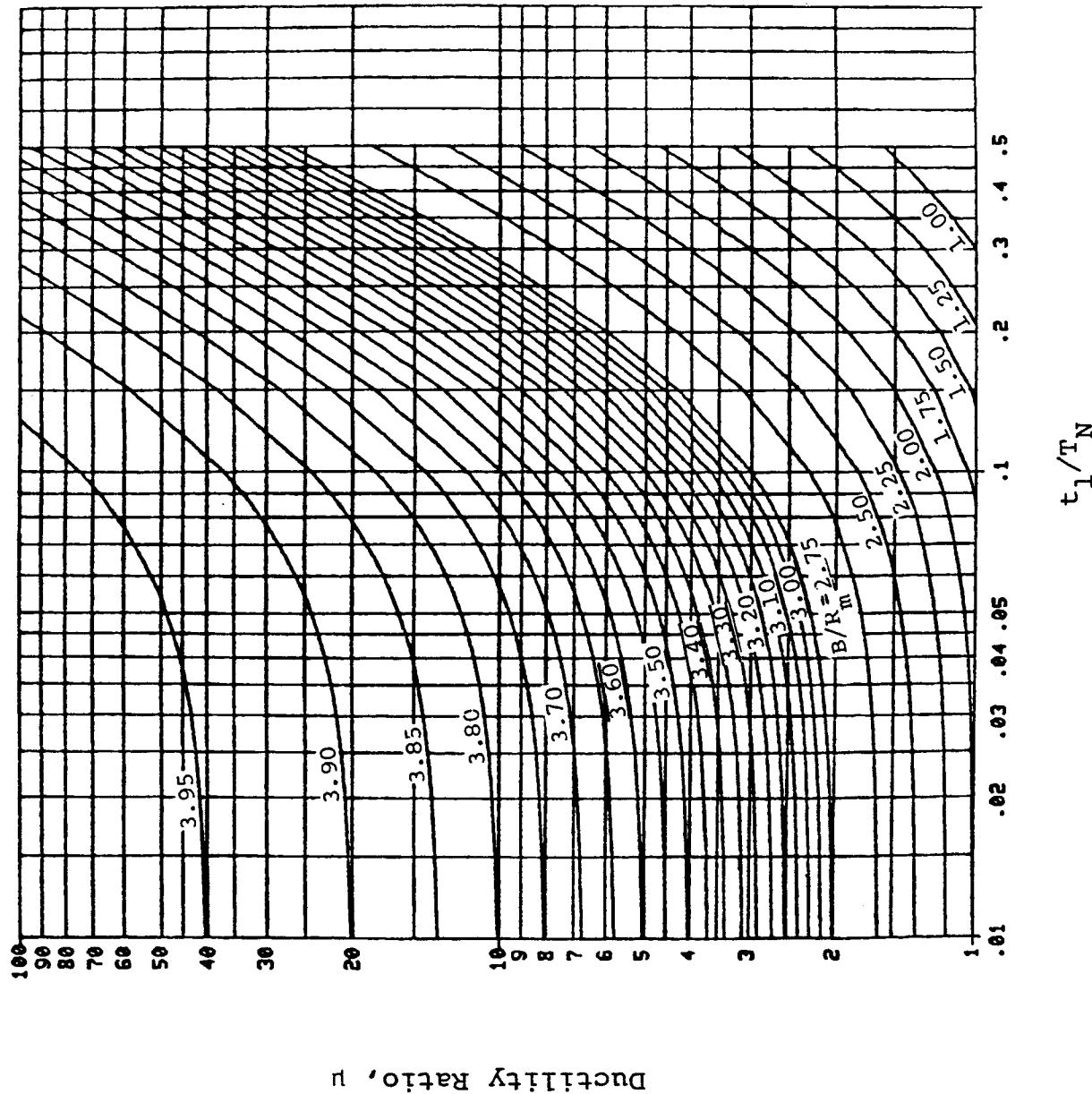


Figure B-16. Response Chart for $C_1 = 0.75$ and $C_2 = 0.25$

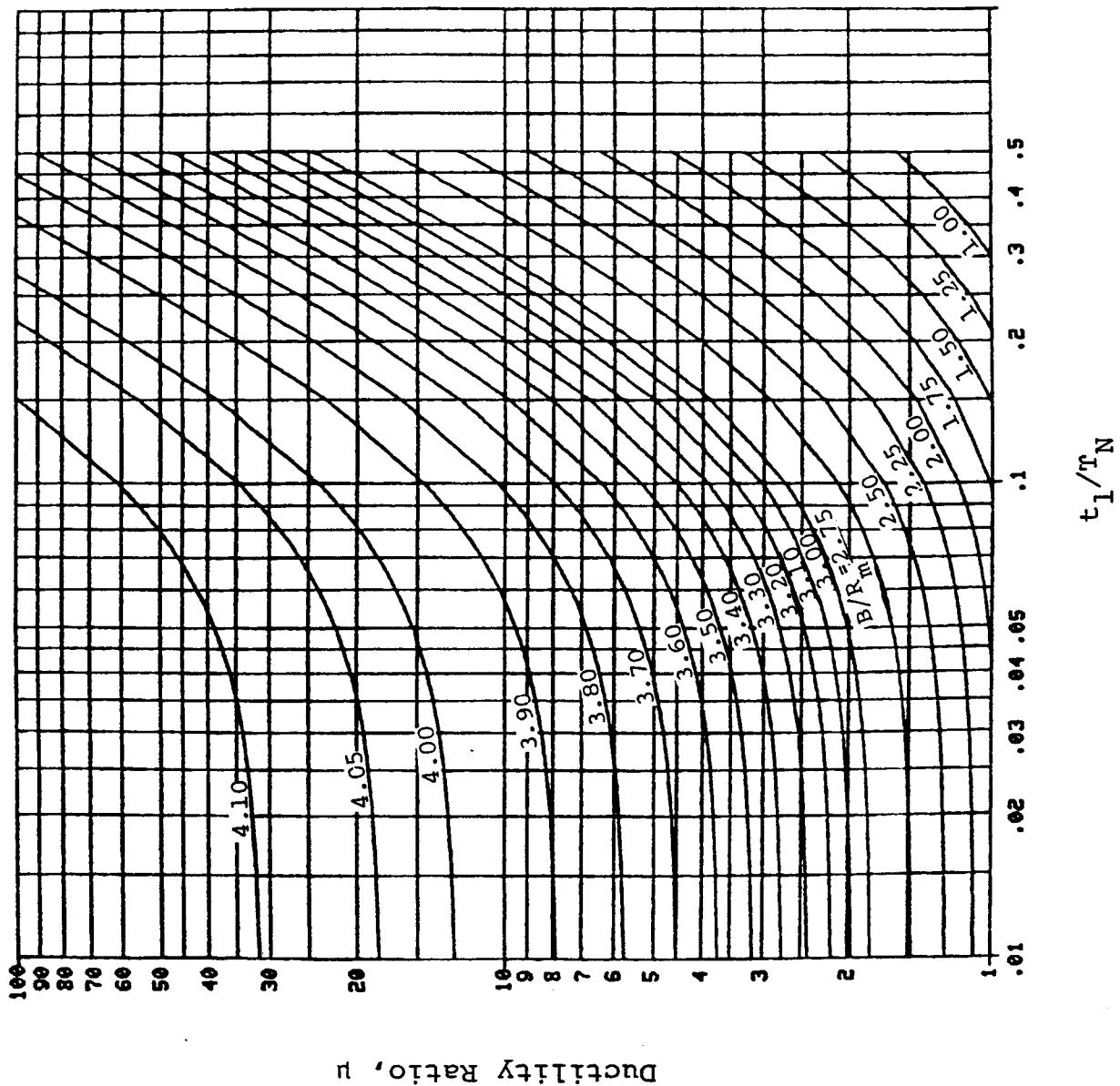


Figure B-17. Response Chart for $C_1 = 0.76$ and $C_2 = 0.24$

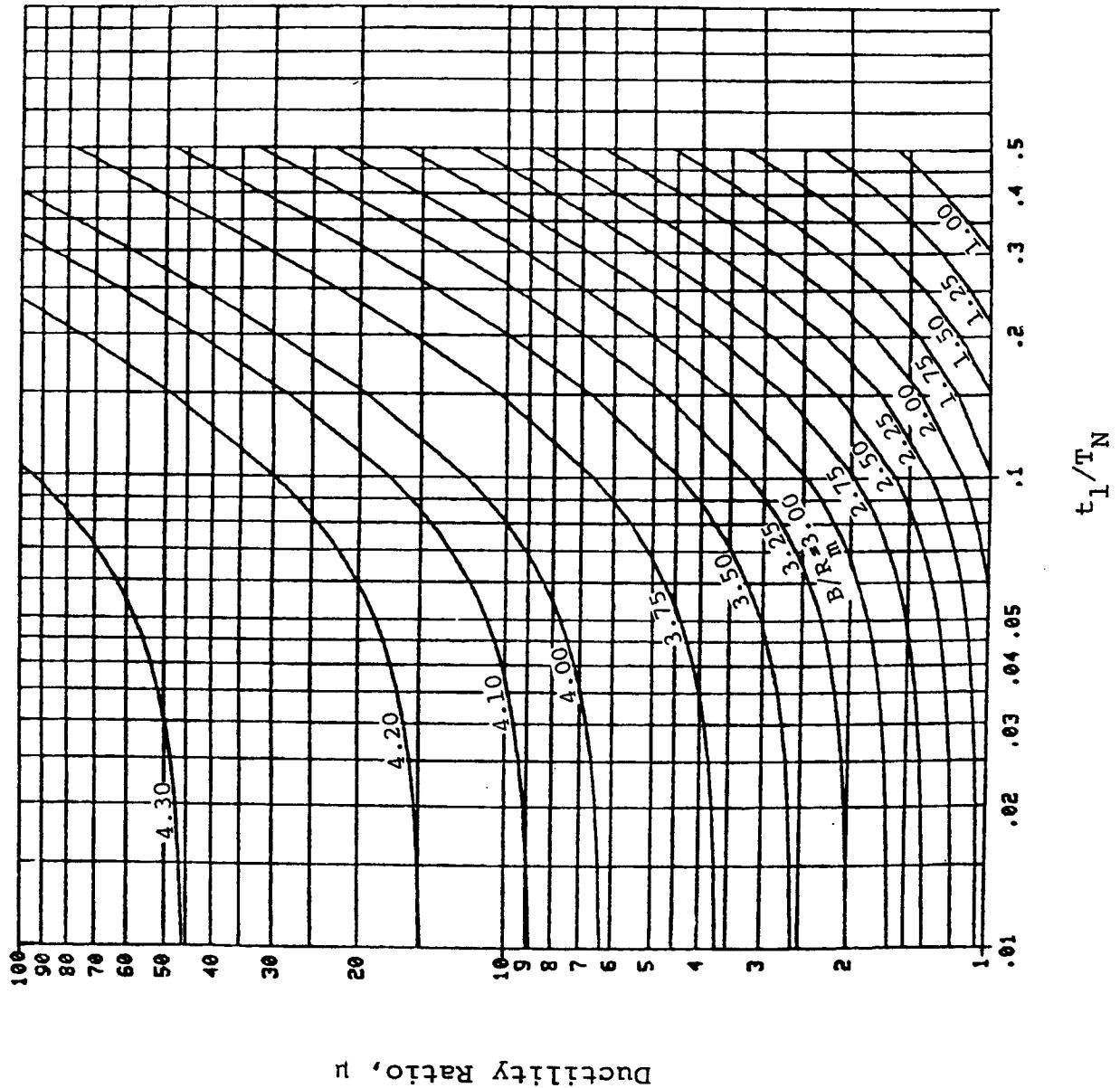


Figure B-18. Response Chart for $C_1 = 0.77$ and $C_2 = 0.23$

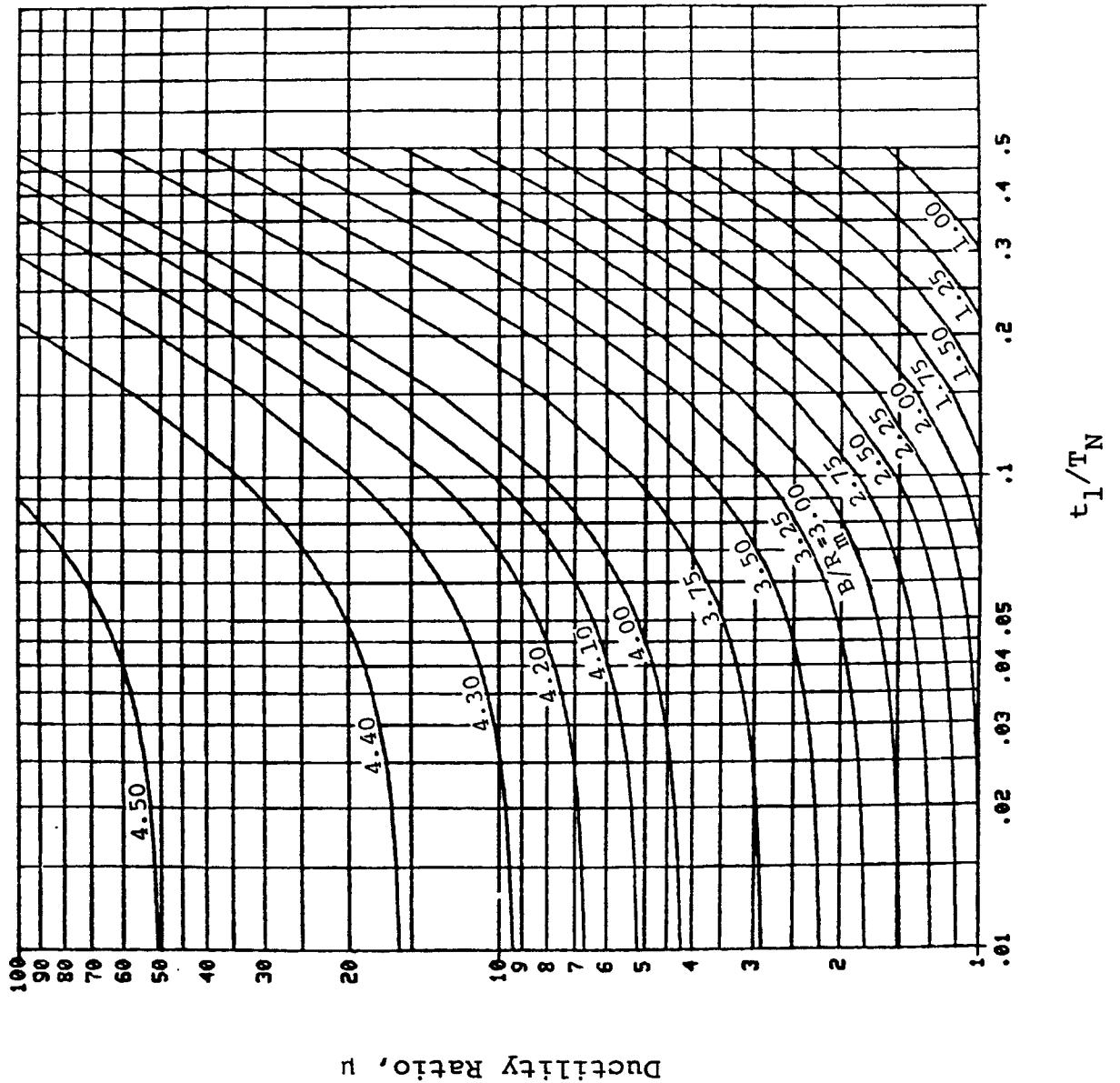


Figure B-19. Response Chart for $C_1 = 0.78$ and $C_2 = 0.22$

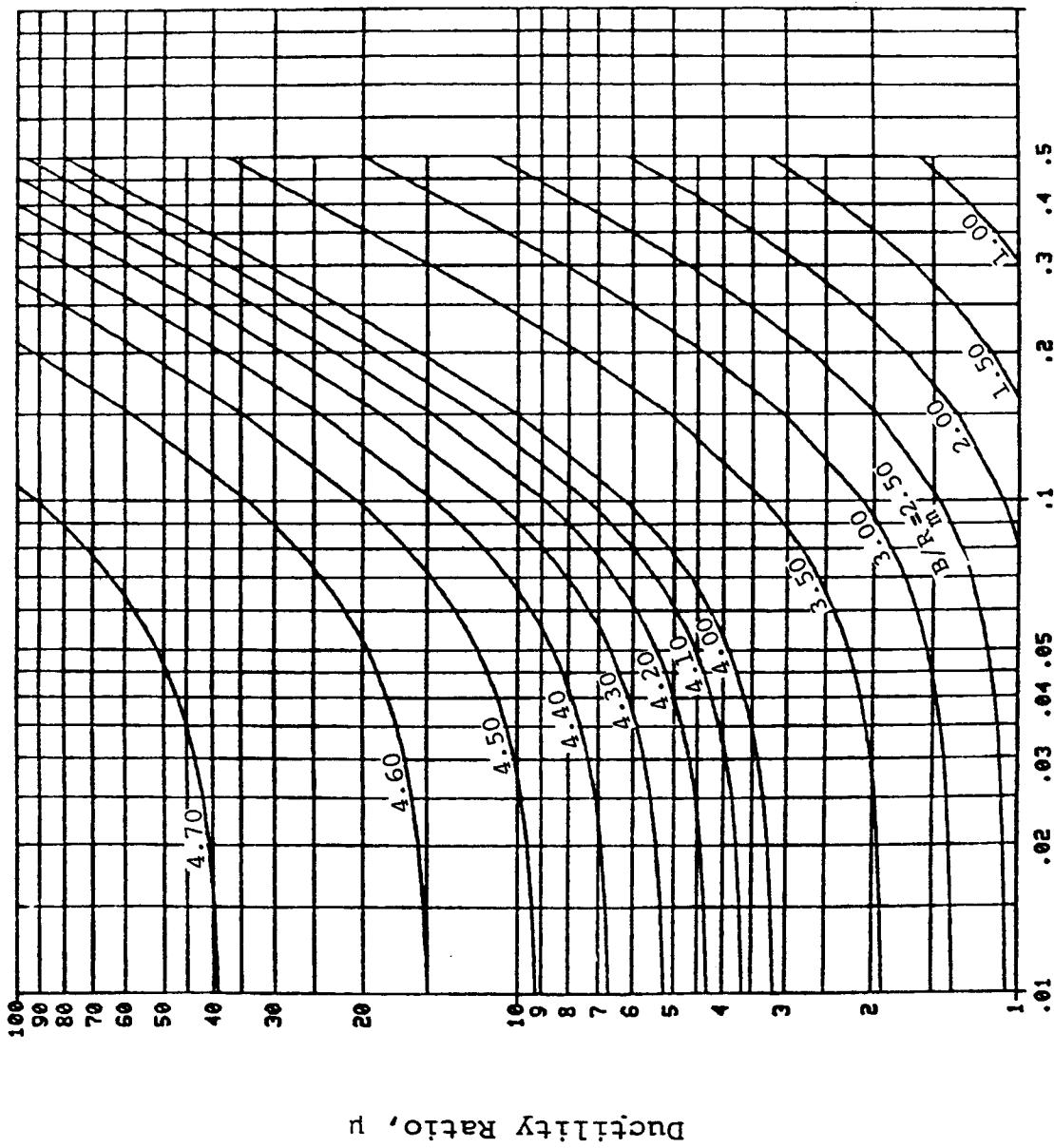


Figure B-20. Response Chart for $C_1 = 0.79$ and $C_2 = 0.21$

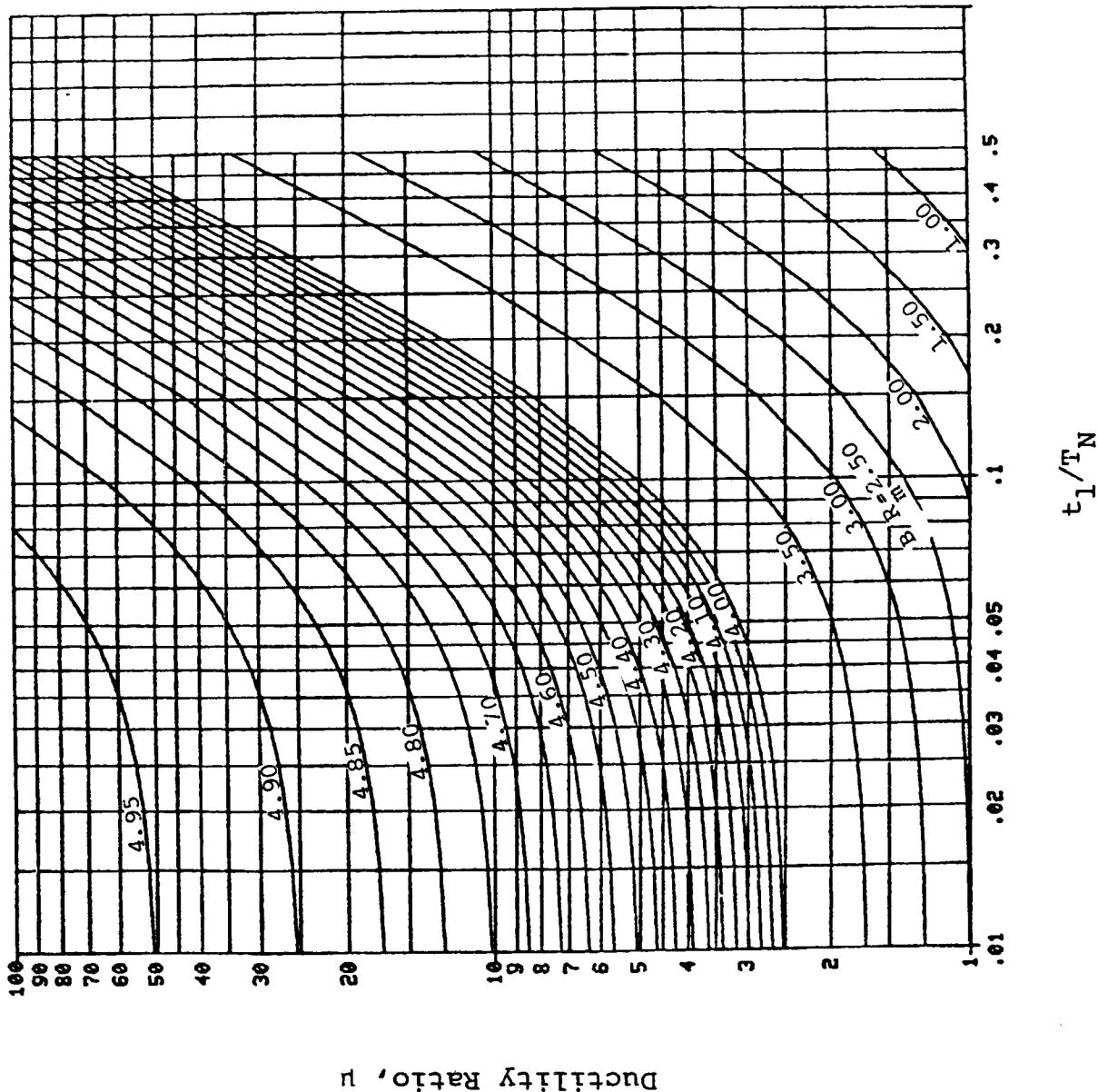


Figure B-21. Response Chart for $C_1 = 0.80$ and $C_2 = 0.20$

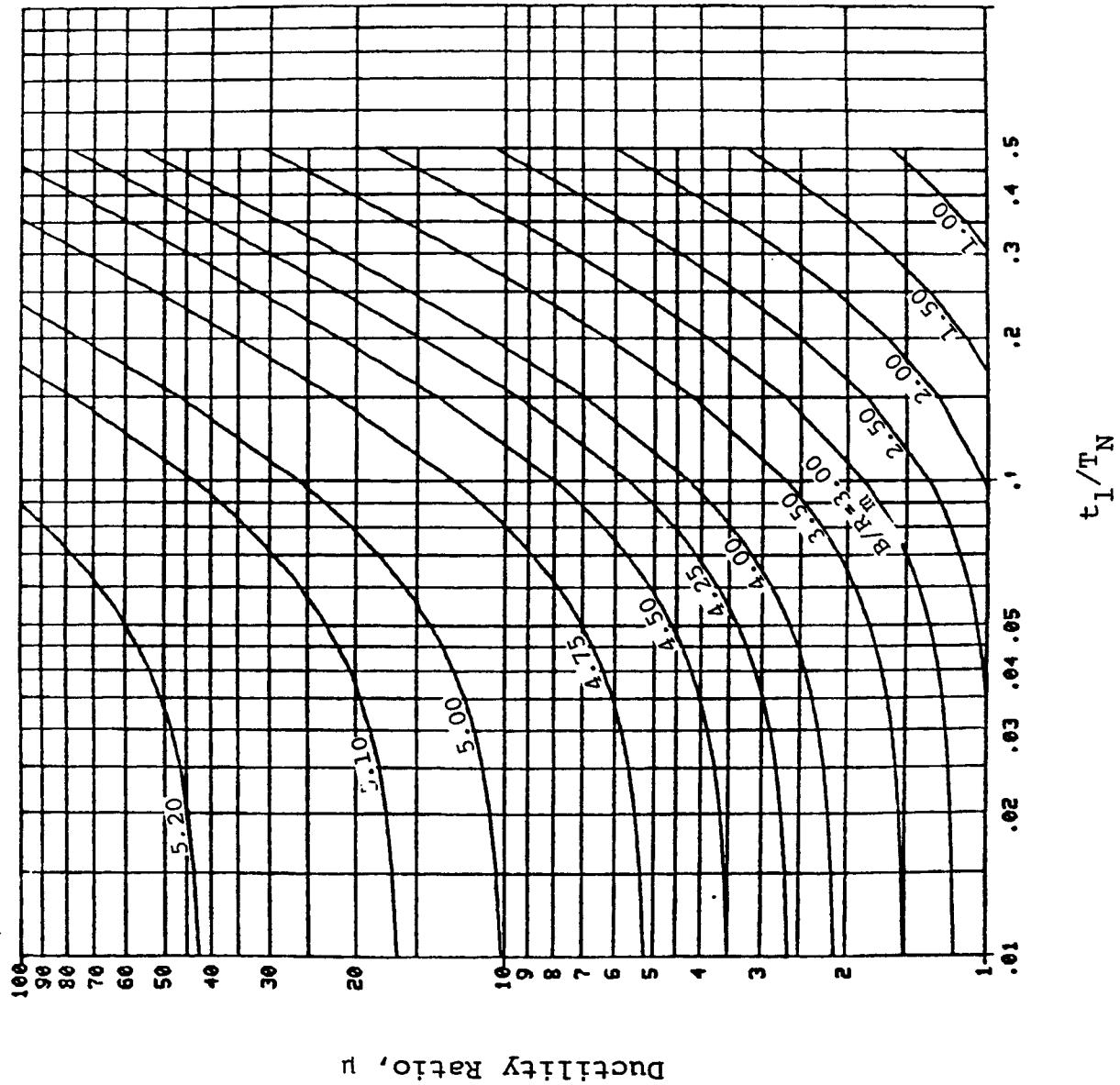


Figure B-22. Response Chart for $C_1 = 0.81$ and $C_2 = 0.19$

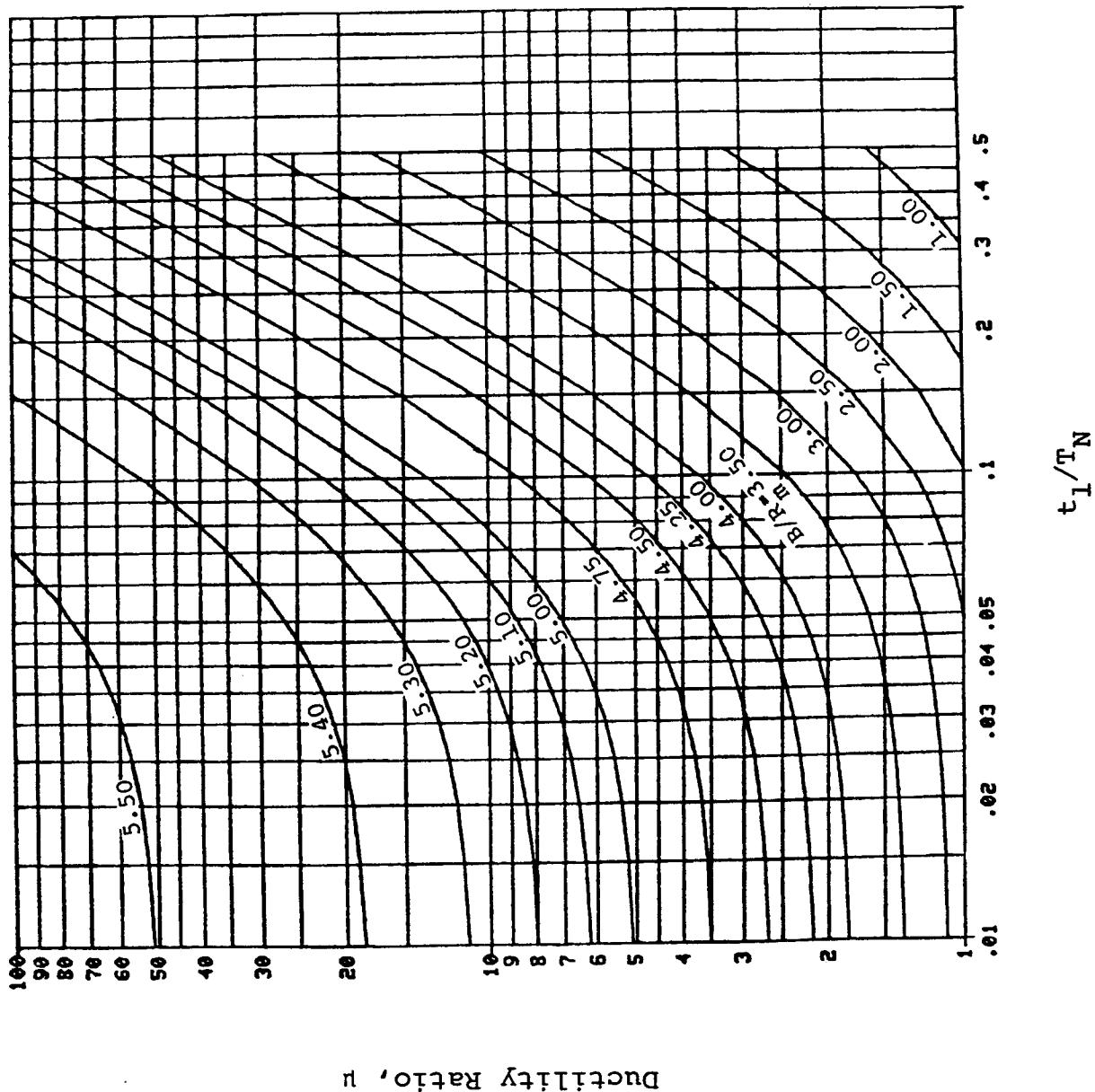


Figure B-23. Response Chart for $C_1 = 0.82$ and $C_2 = 0.18$

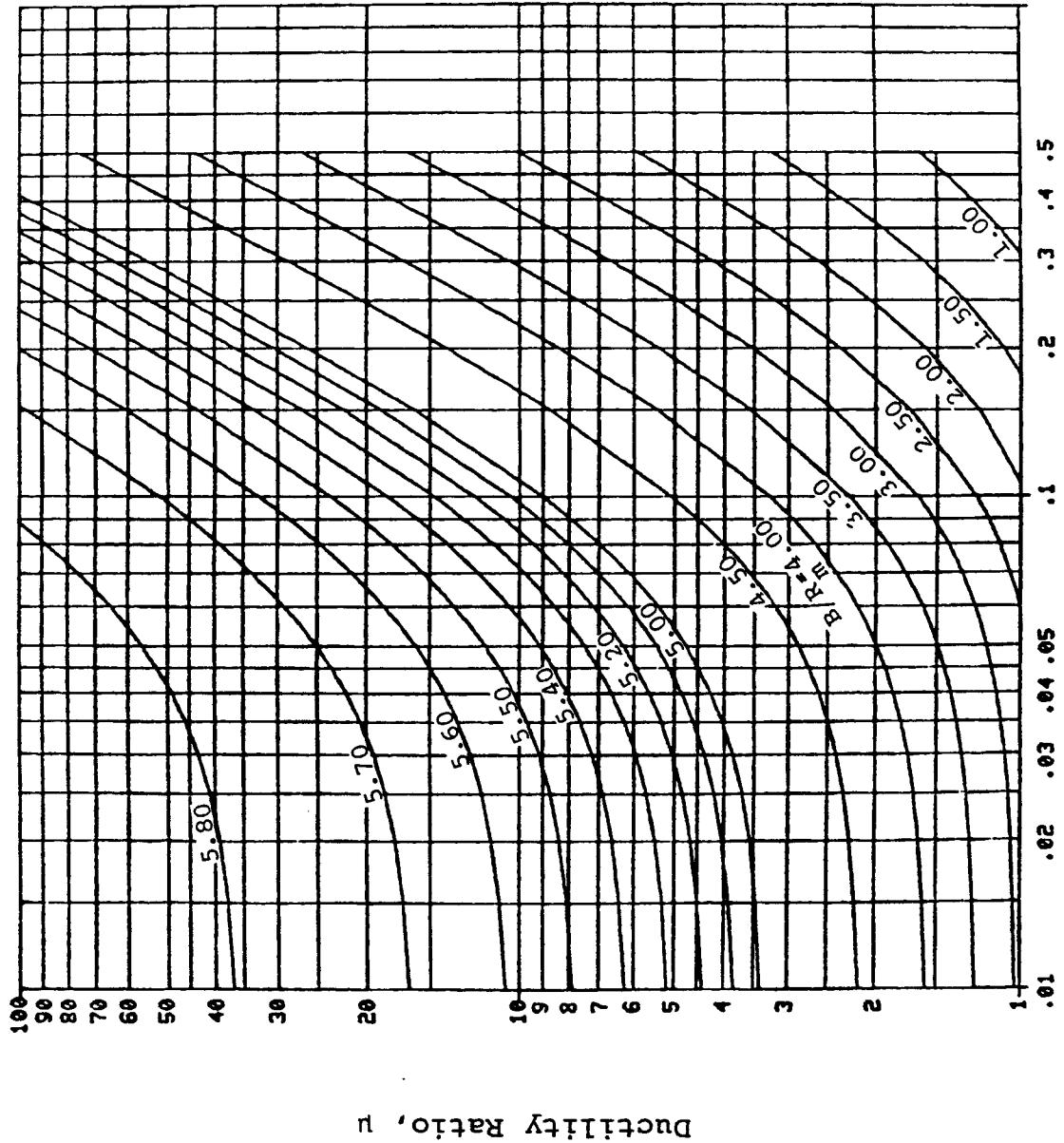


Figure B-24. Response Chart for $C_1 = 0.83$ and $C_2 = 0.17$

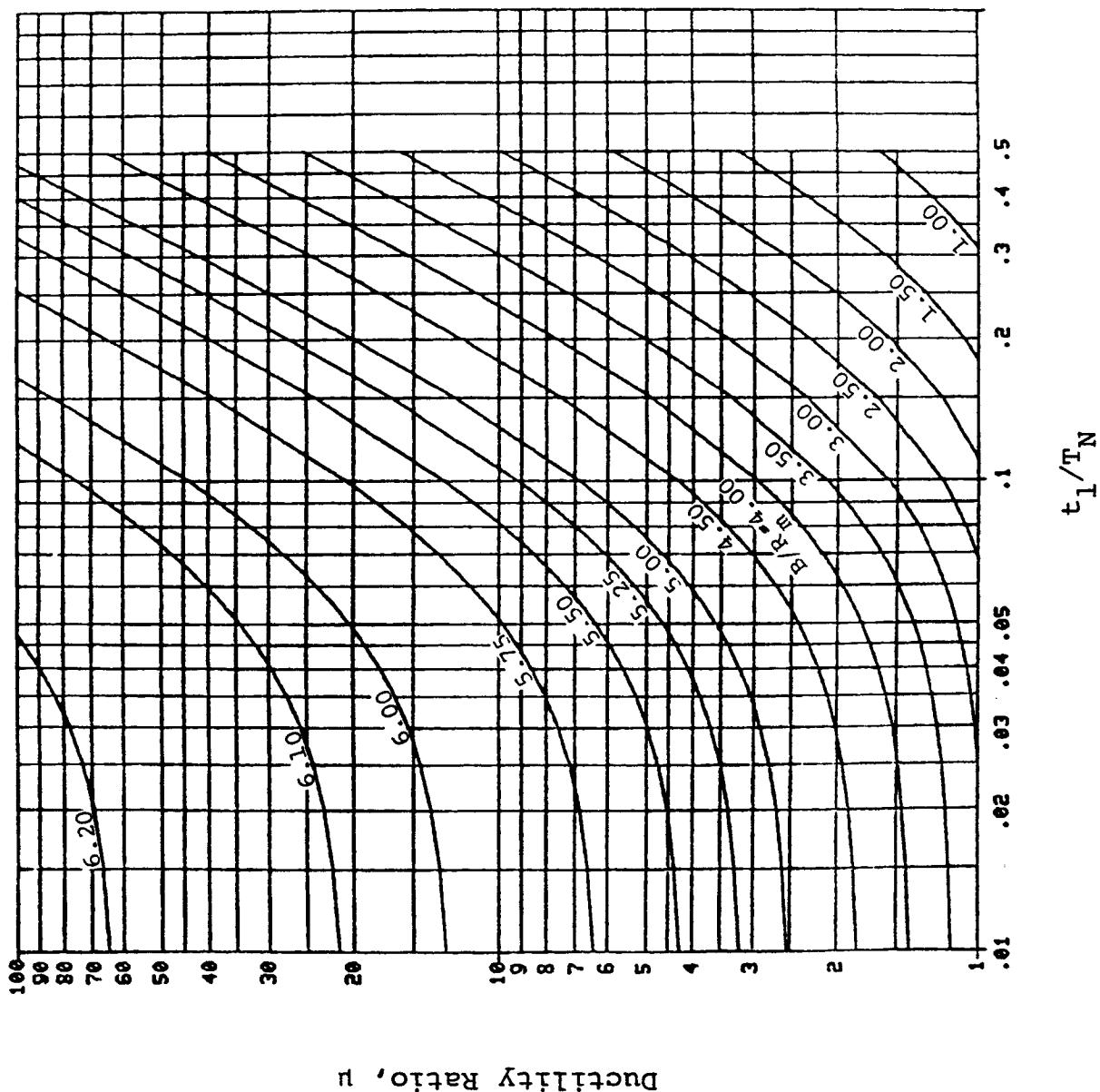


Figure B-25. Response Chart for $C_1 = 0.84$ and $C_2 = 0.16$

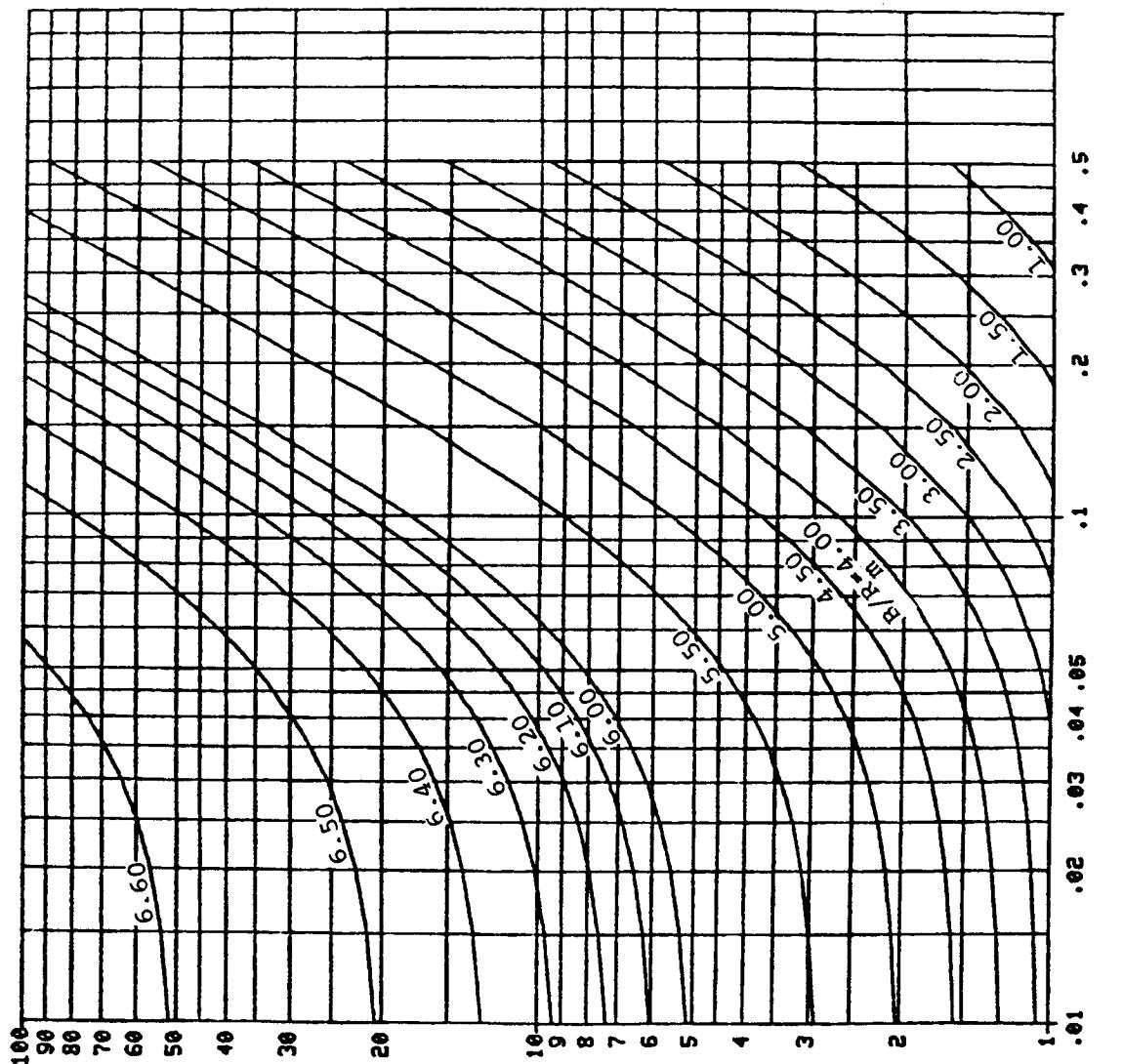
DUCTILITY RATIO, μ

Figure B-26. Response Chart for $C_1 = 0.85$ and $C_2 = 0.15$

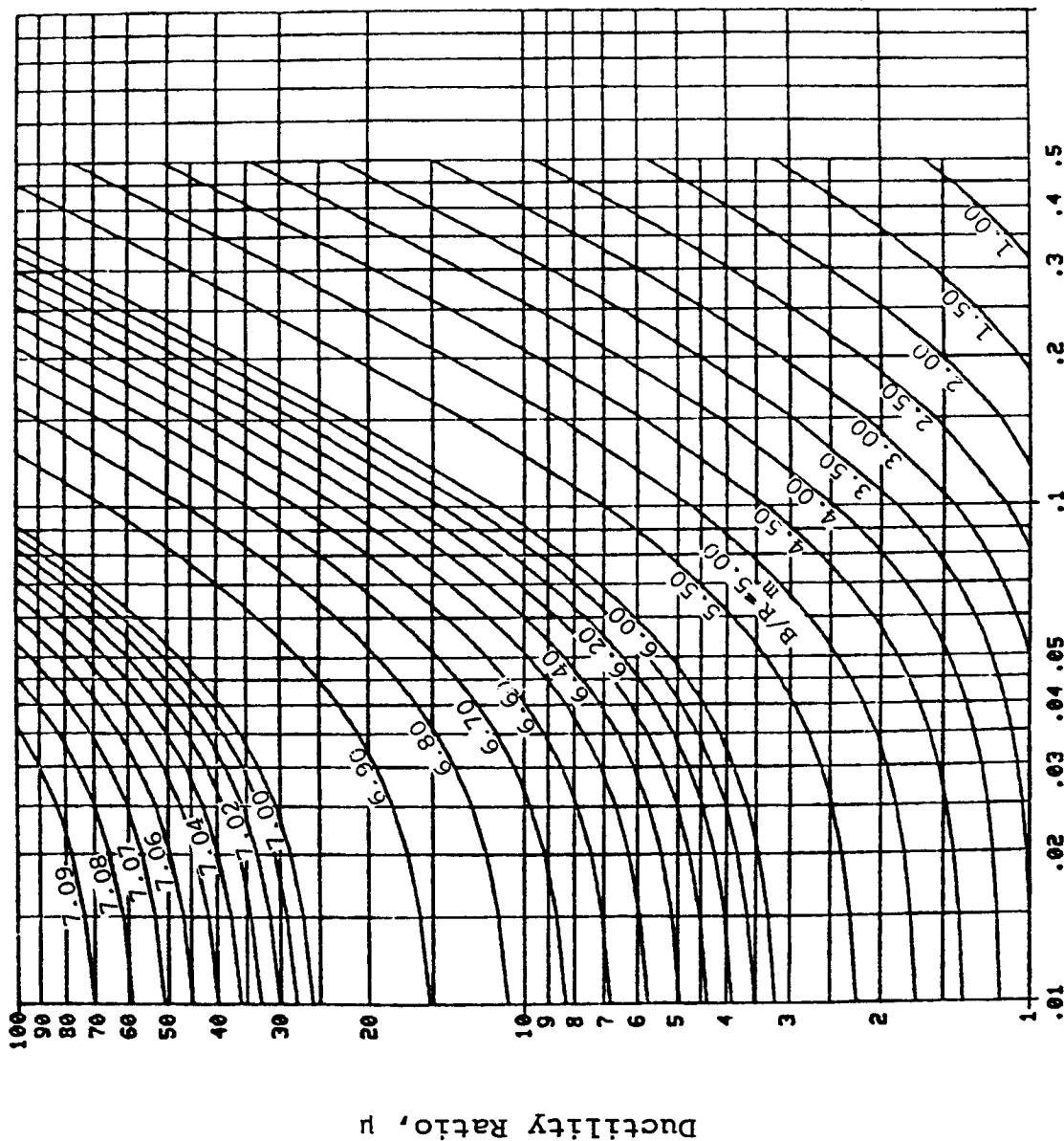


Figure B-27. Response Chart for $C_1 = 0.86$ and $C_2 = 0.14$

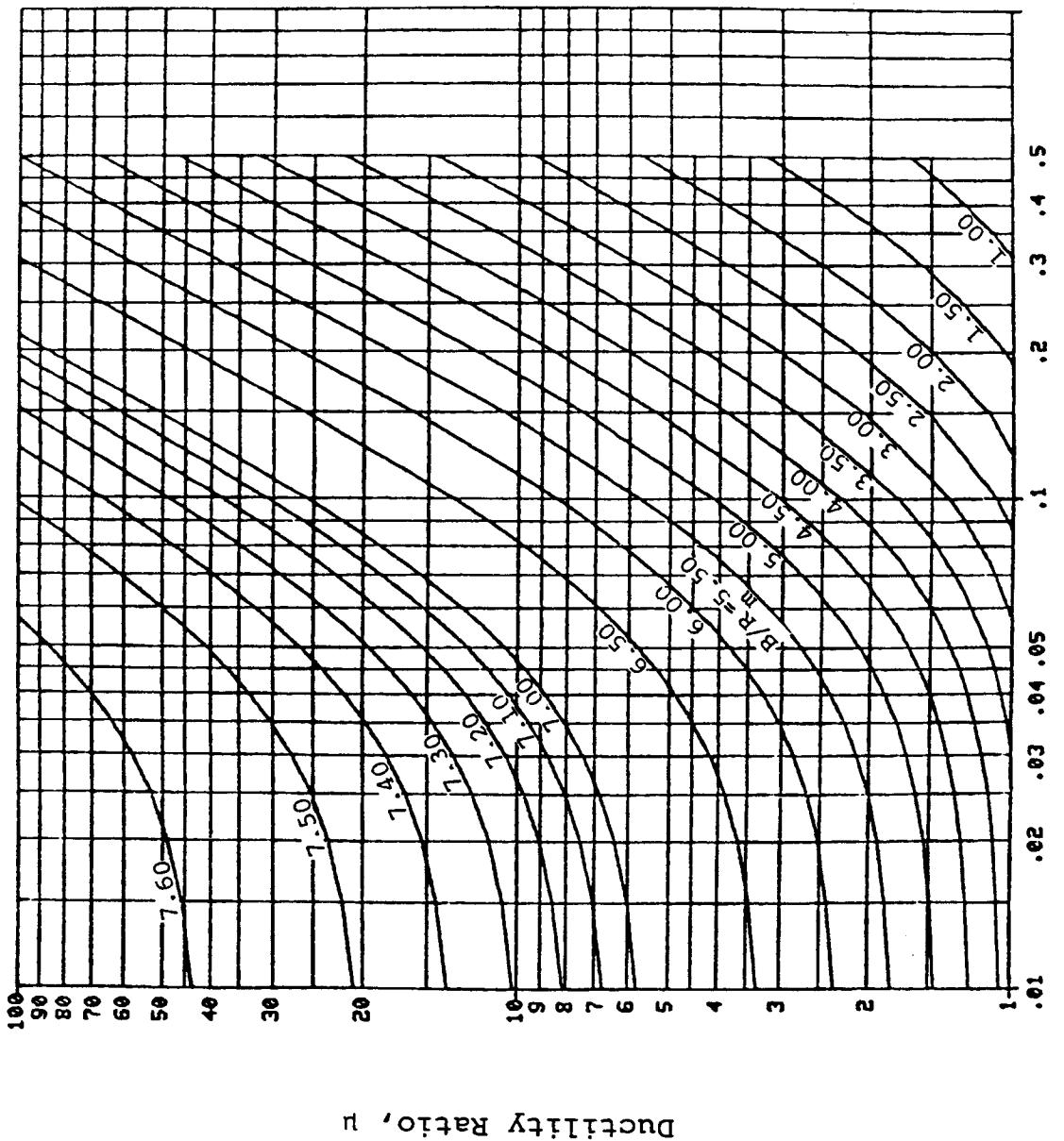
DUCTILITY RATIO, μ

Figure B-28. Response Chart for $C_1 = 0.87$ and $C_2 = 0.13$

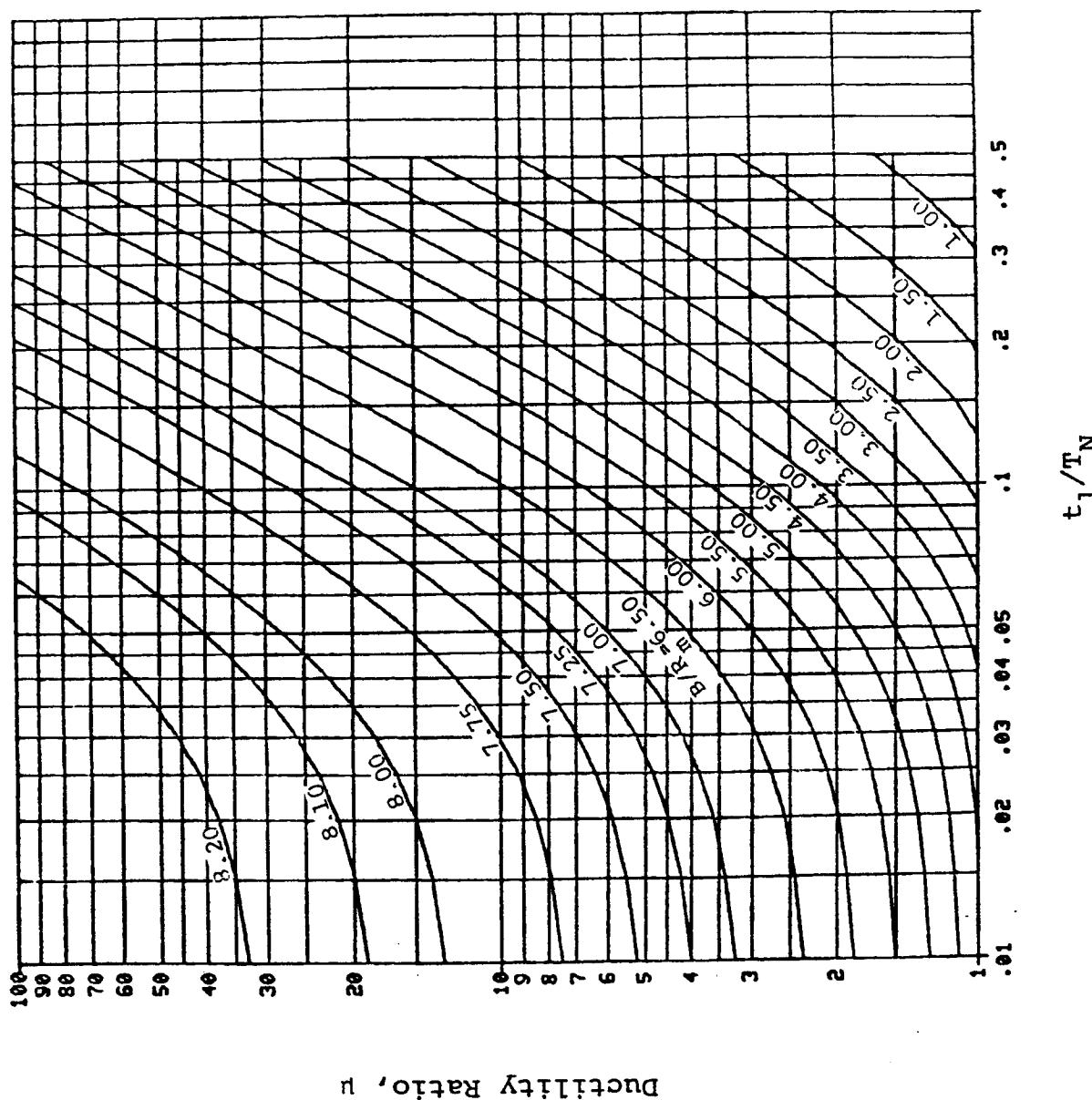


Figure B-29. Response Chart for $C_1 = 0.88$ and $C_2 = 0.12$

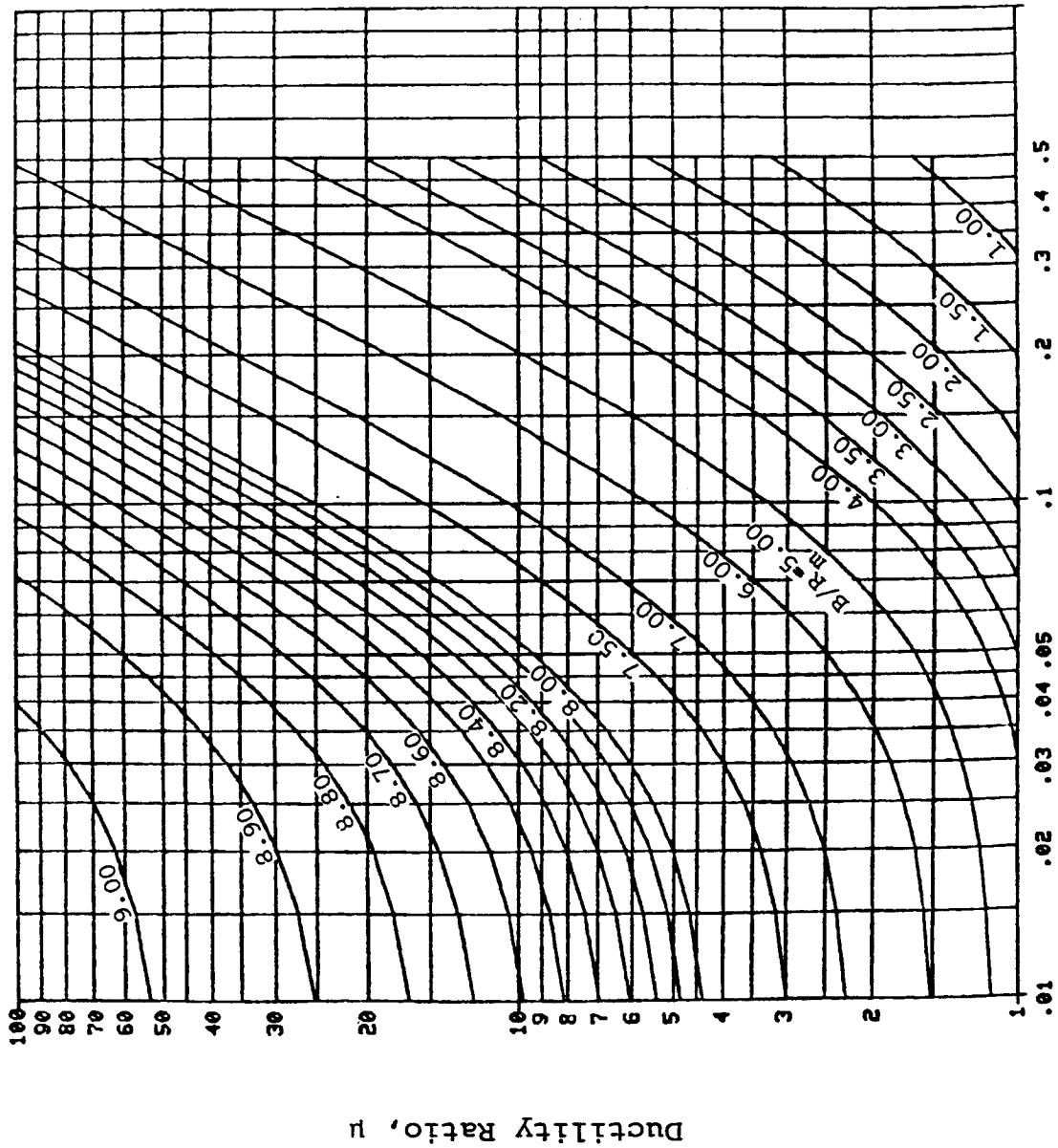


Figure B-30. Response Chart for $C_1 = 0.89$ and $C_2 = 0.11$

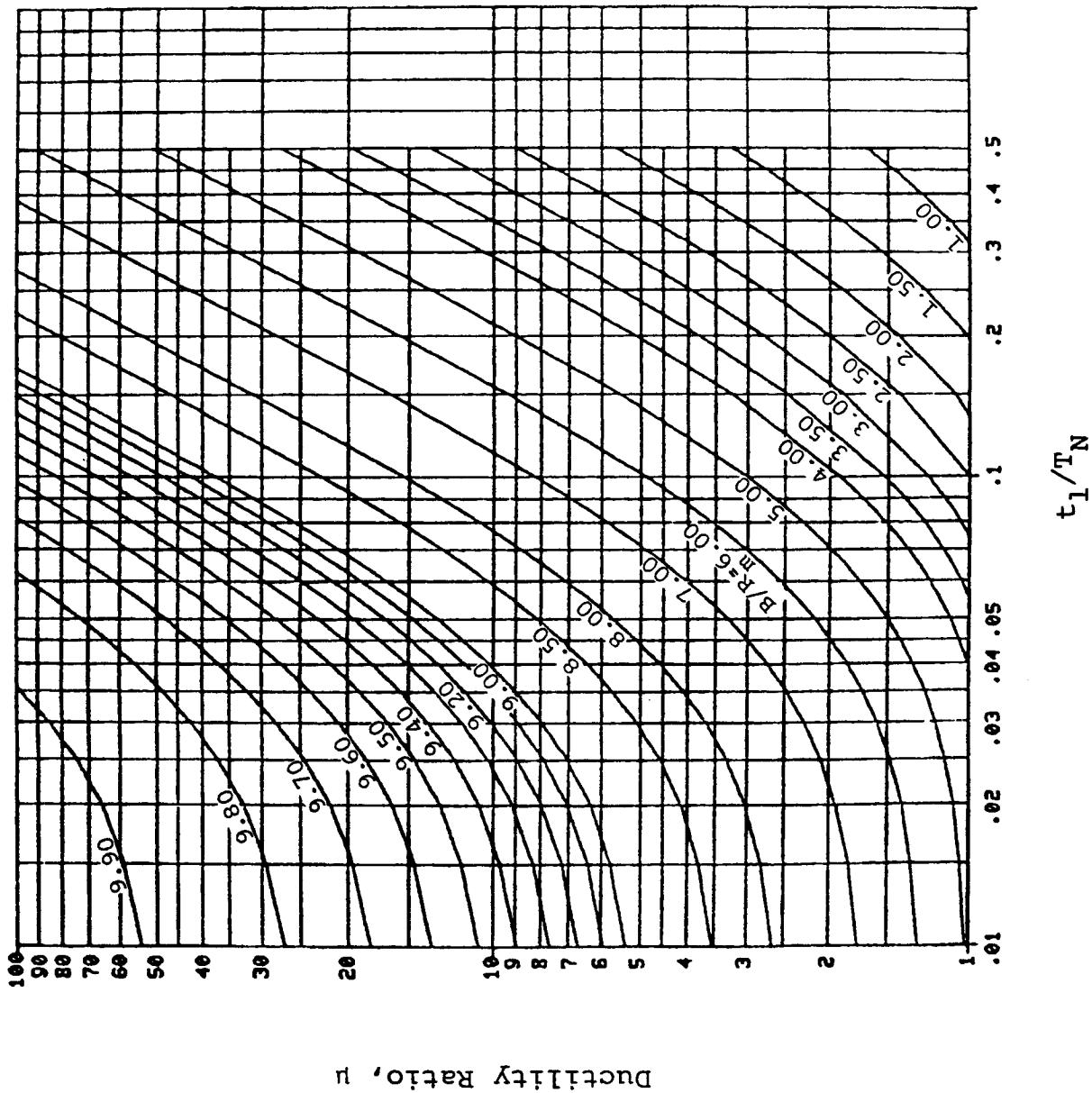


Figure B-31. Response Chart for $C_1 = 0.90$ and $C_2 = 0.10$

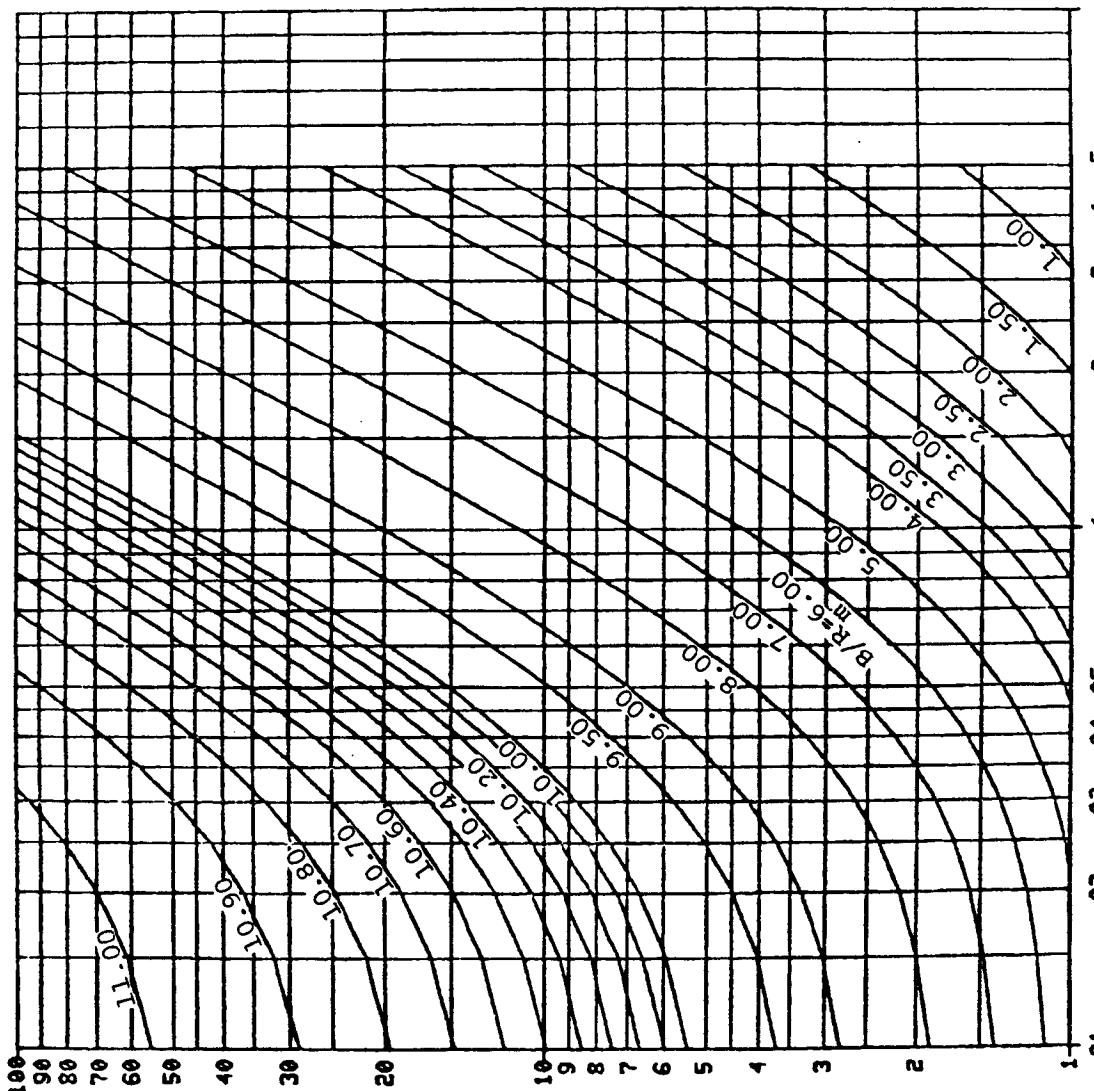


Figure B-32. Response Chart for $C_1 = 0.91$ and $C_2 = 0.09$

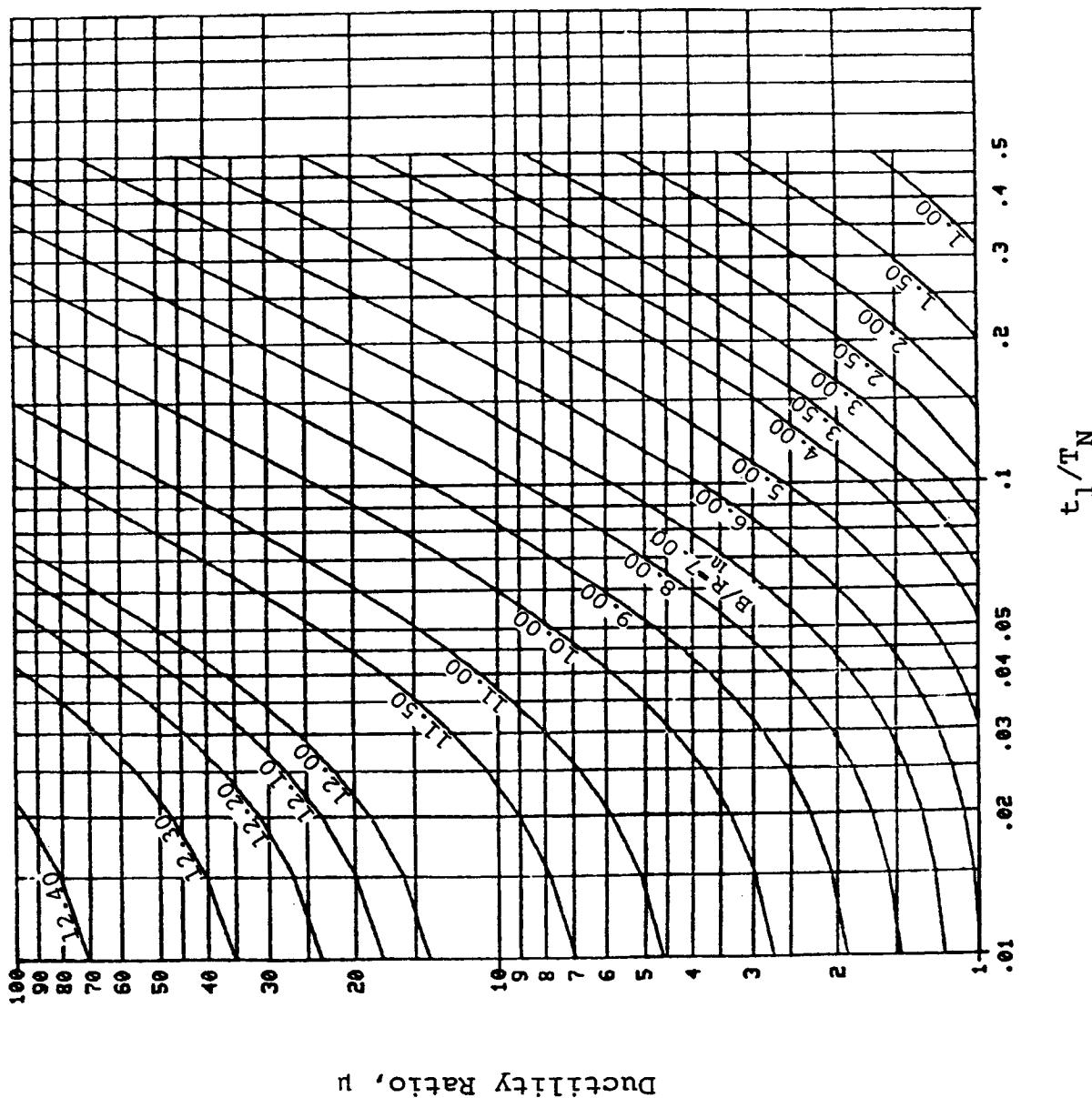


Figure B-33. Response Chart for $C_1 = 0.92$ and $C_2 = 0.08$

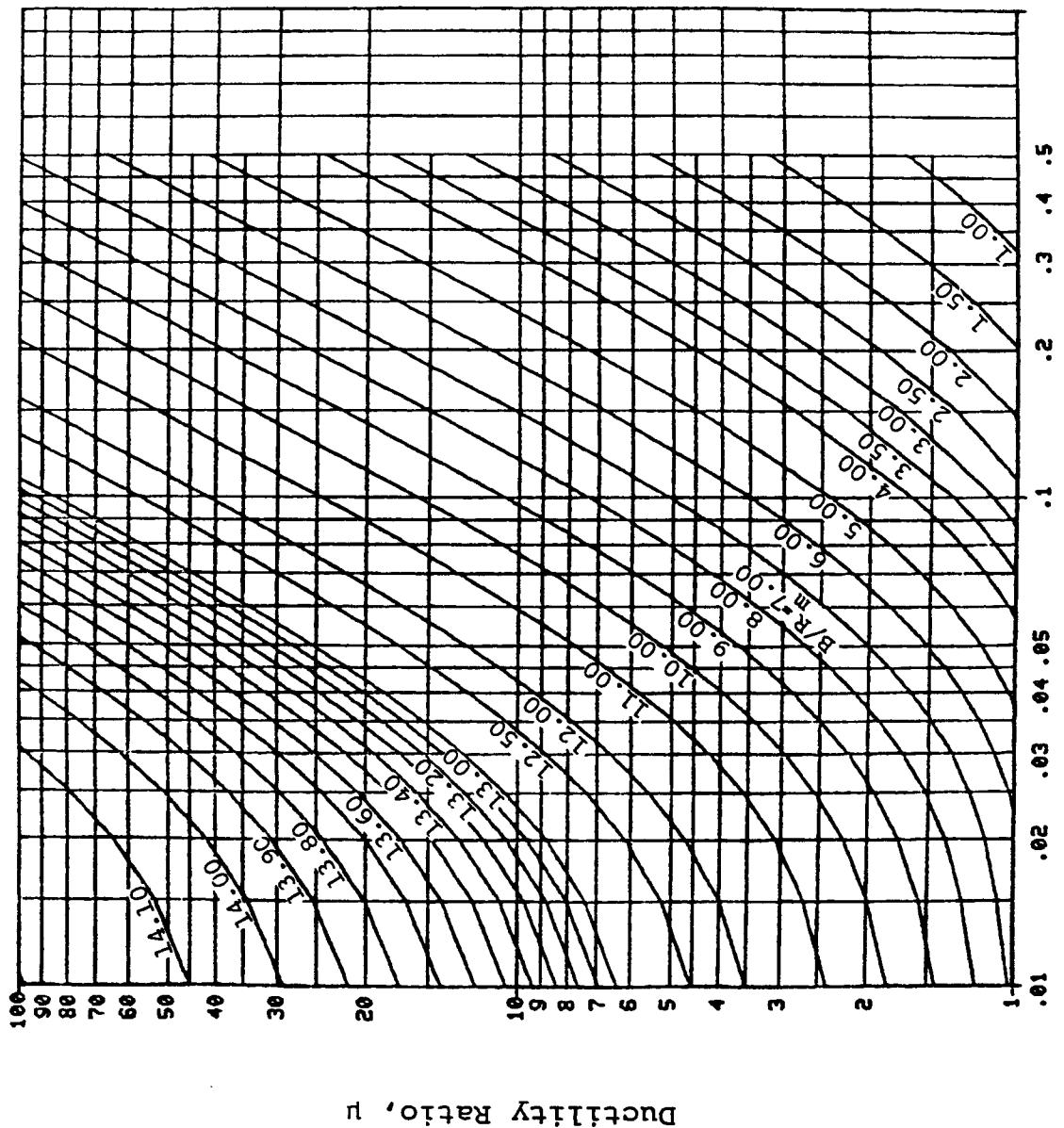


Figure B-34. Response Chart for $C_1 = 0.93$ and $C_2 = 0.07$

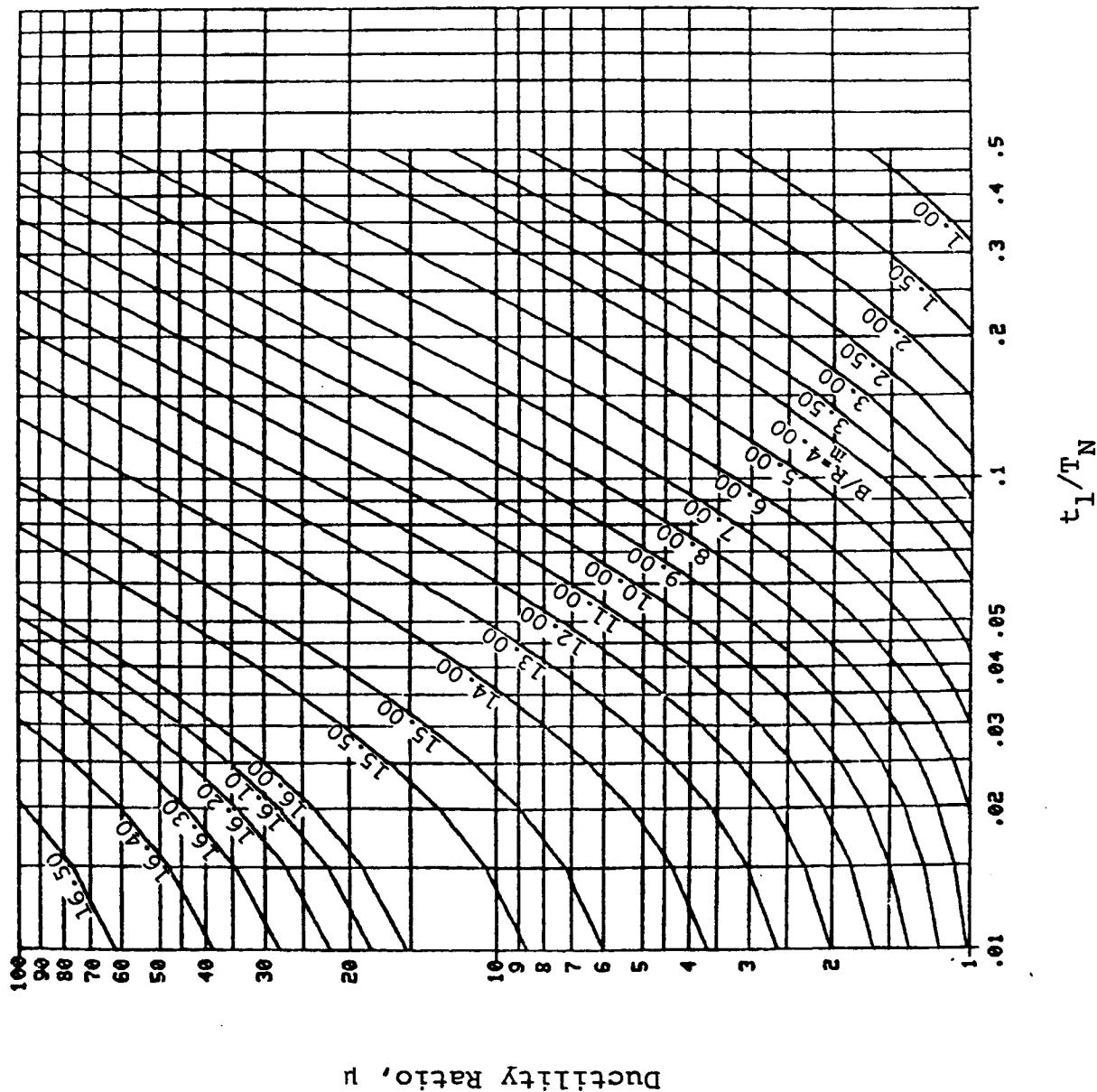
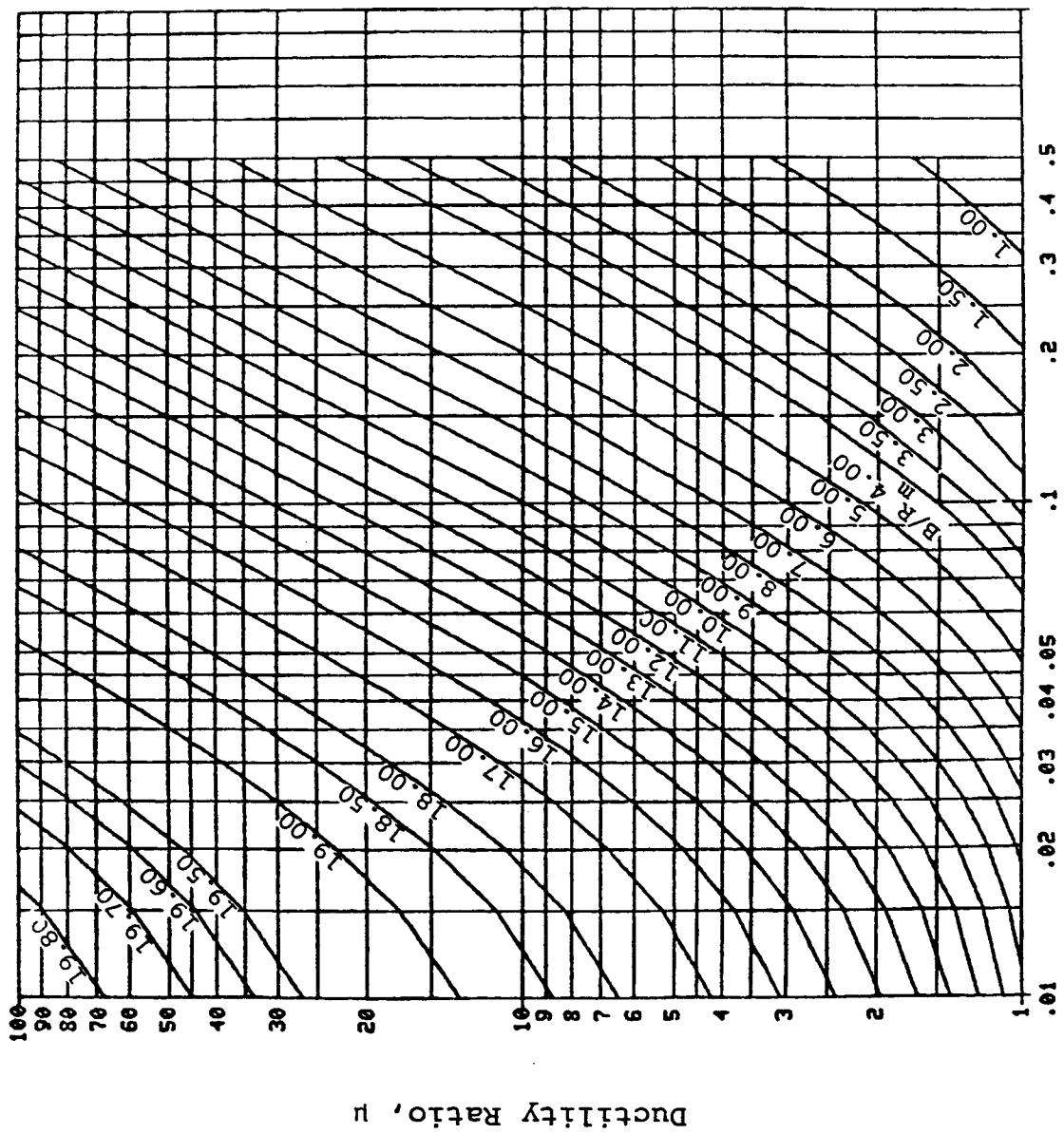


Figure B-35. Response Chart for $C_1 = 0.94$ and $C_2 = 0.06$

Figure B-36. Response Chart for $C_1 = 0.95$ and $C_2 = 0.05$

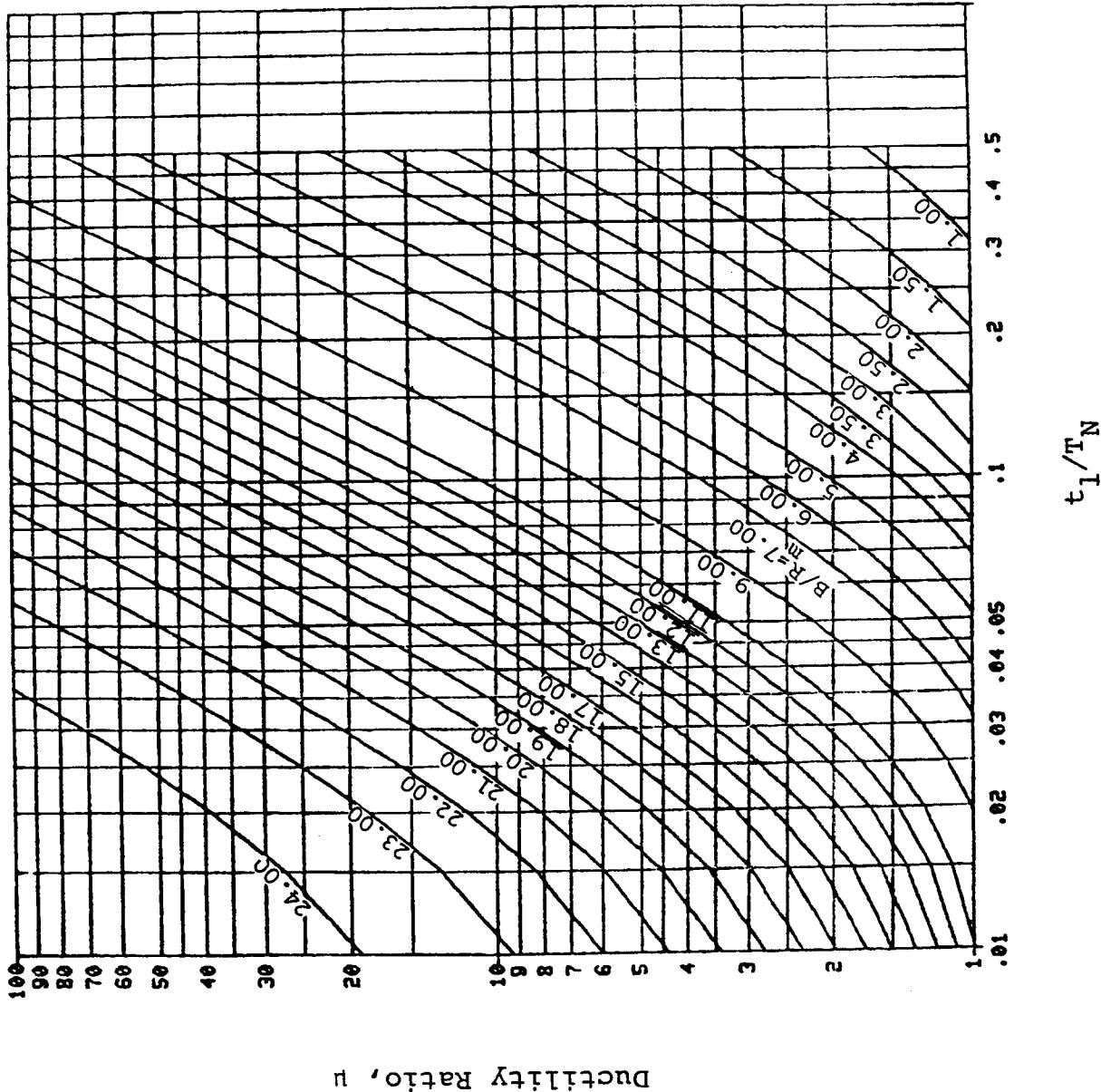
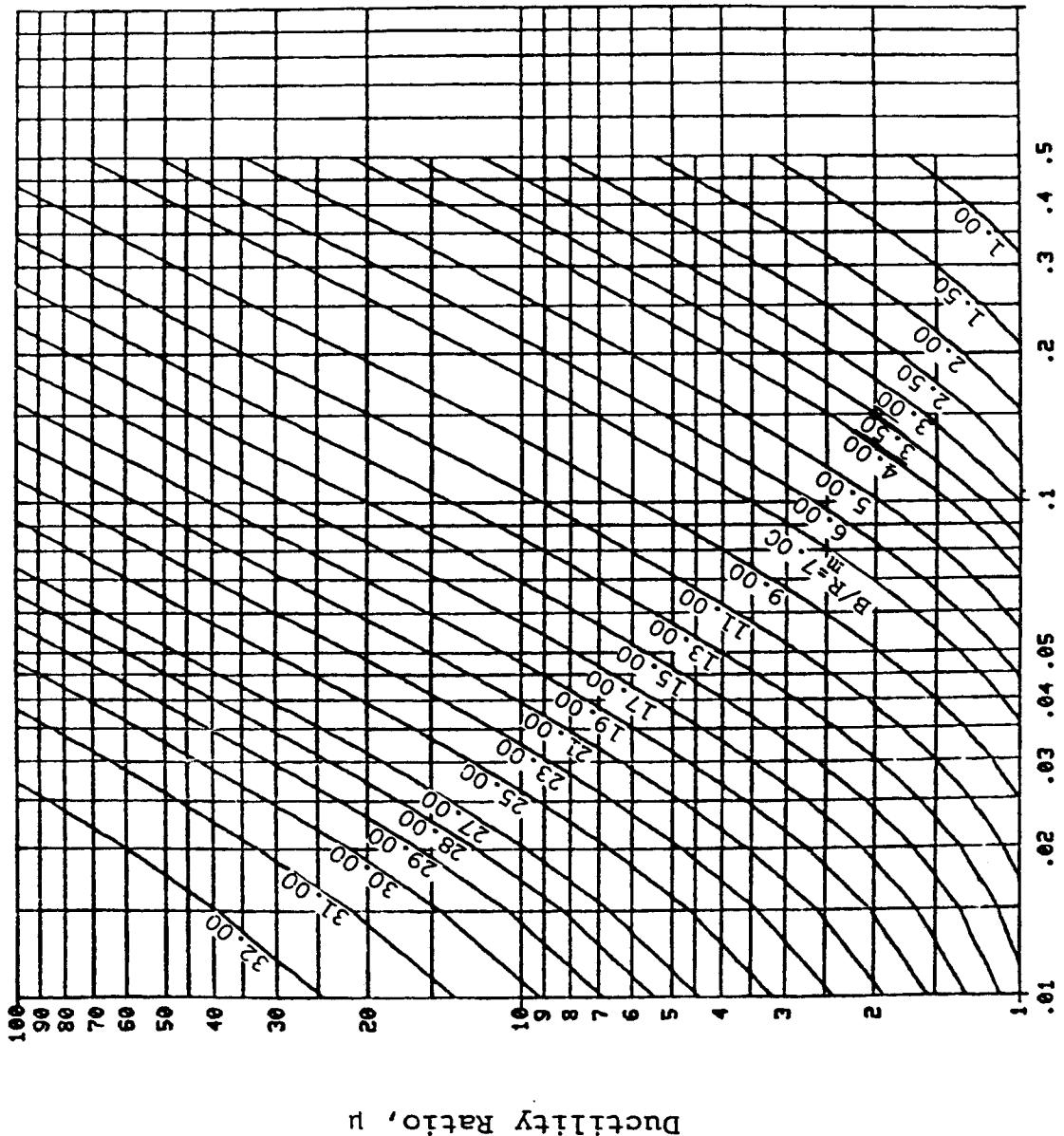


Figure B-37. Response Chart for $C_1 = 0.96$ and $C_2 = 0.04$

Ductility Ratio, μ Figure B-38. Response Chart for $C_1 = 0.97$ and $C_2 = 0.03$

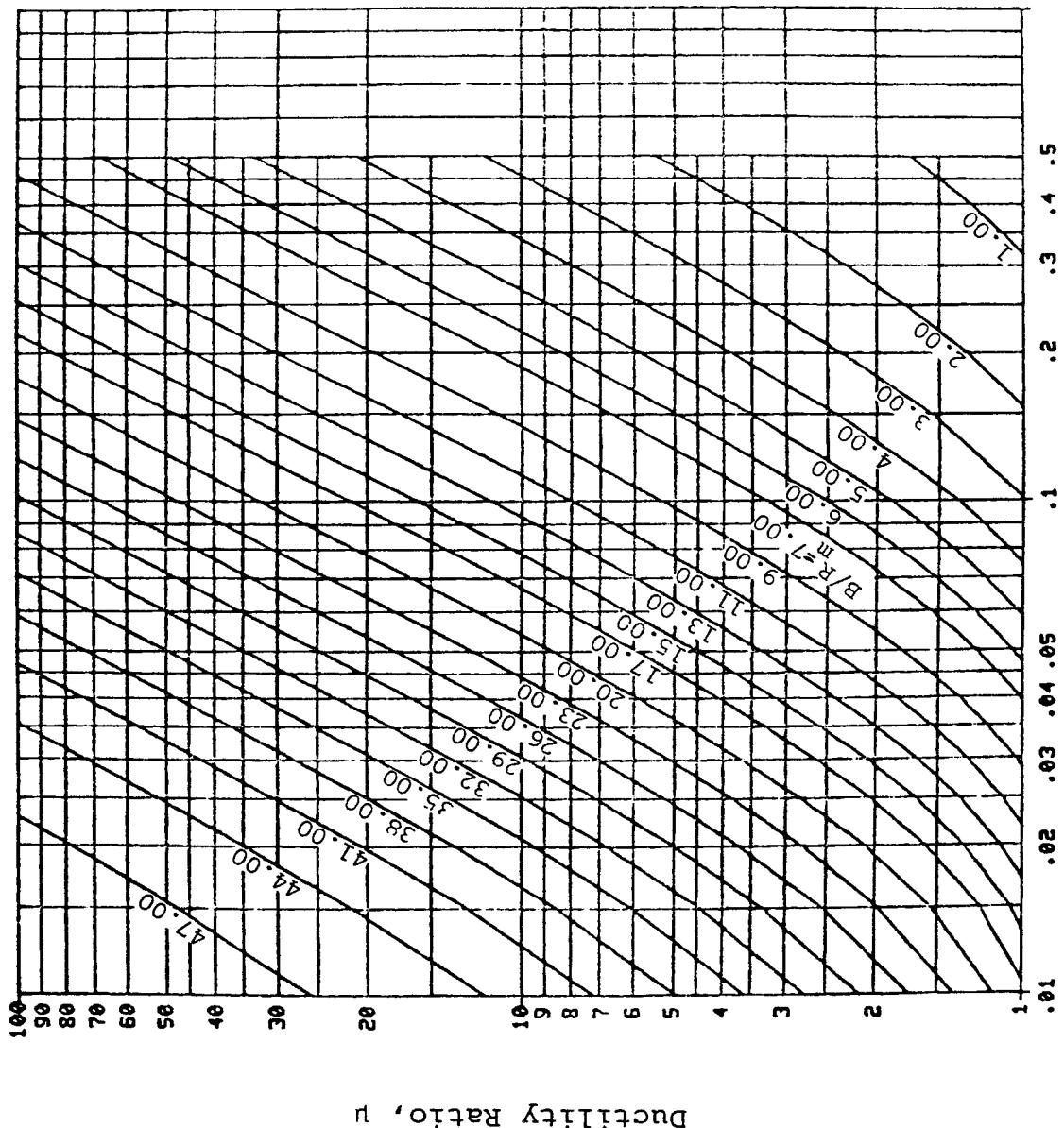
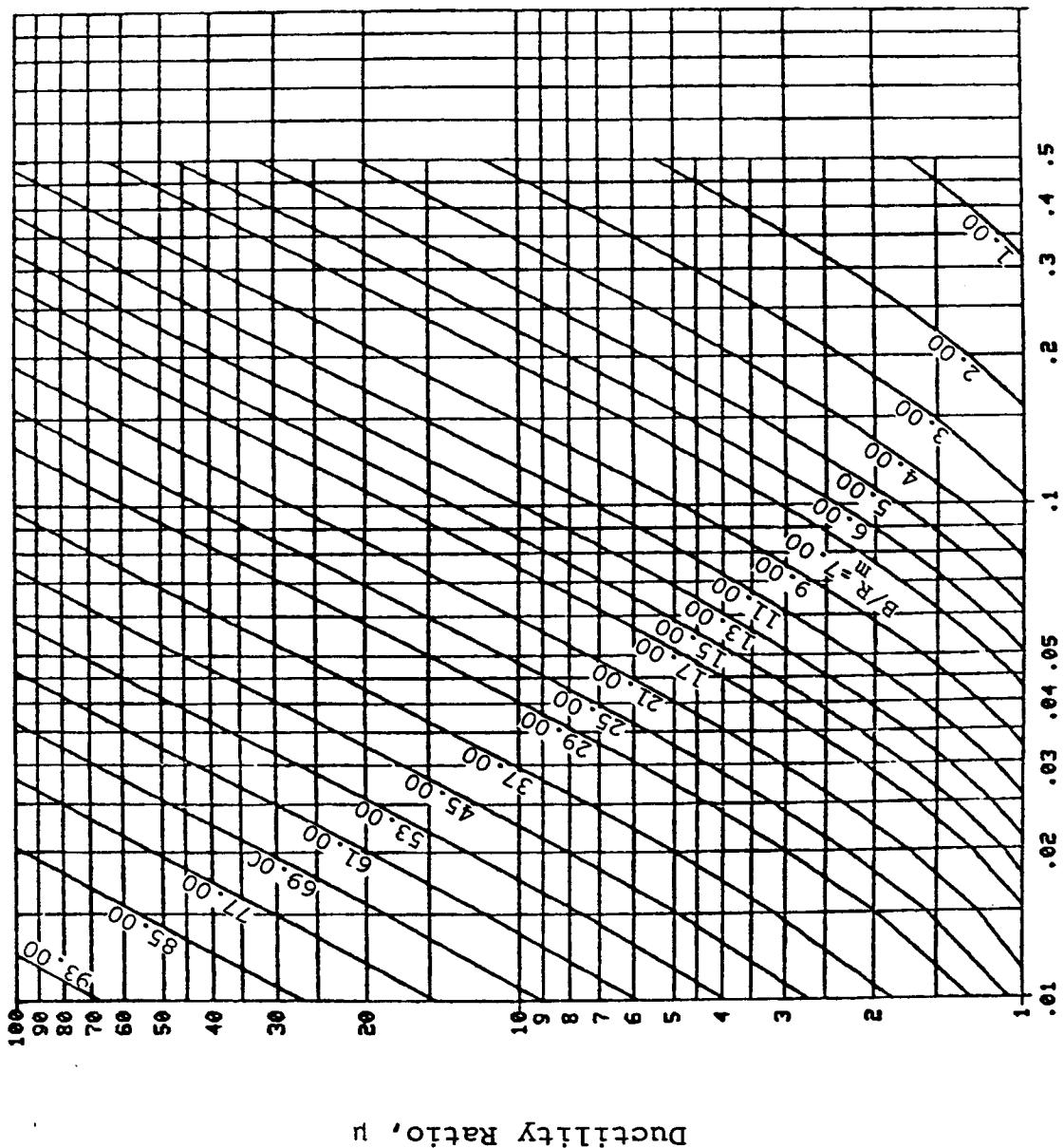


Figure B-39. Response Chart for $C_1 = 0.98$ and $C_2 = 0.02$

 t_1/T_N Figure B-40. Response Chart for $C_1 = 0.99$ and $C_2 = 0.01$

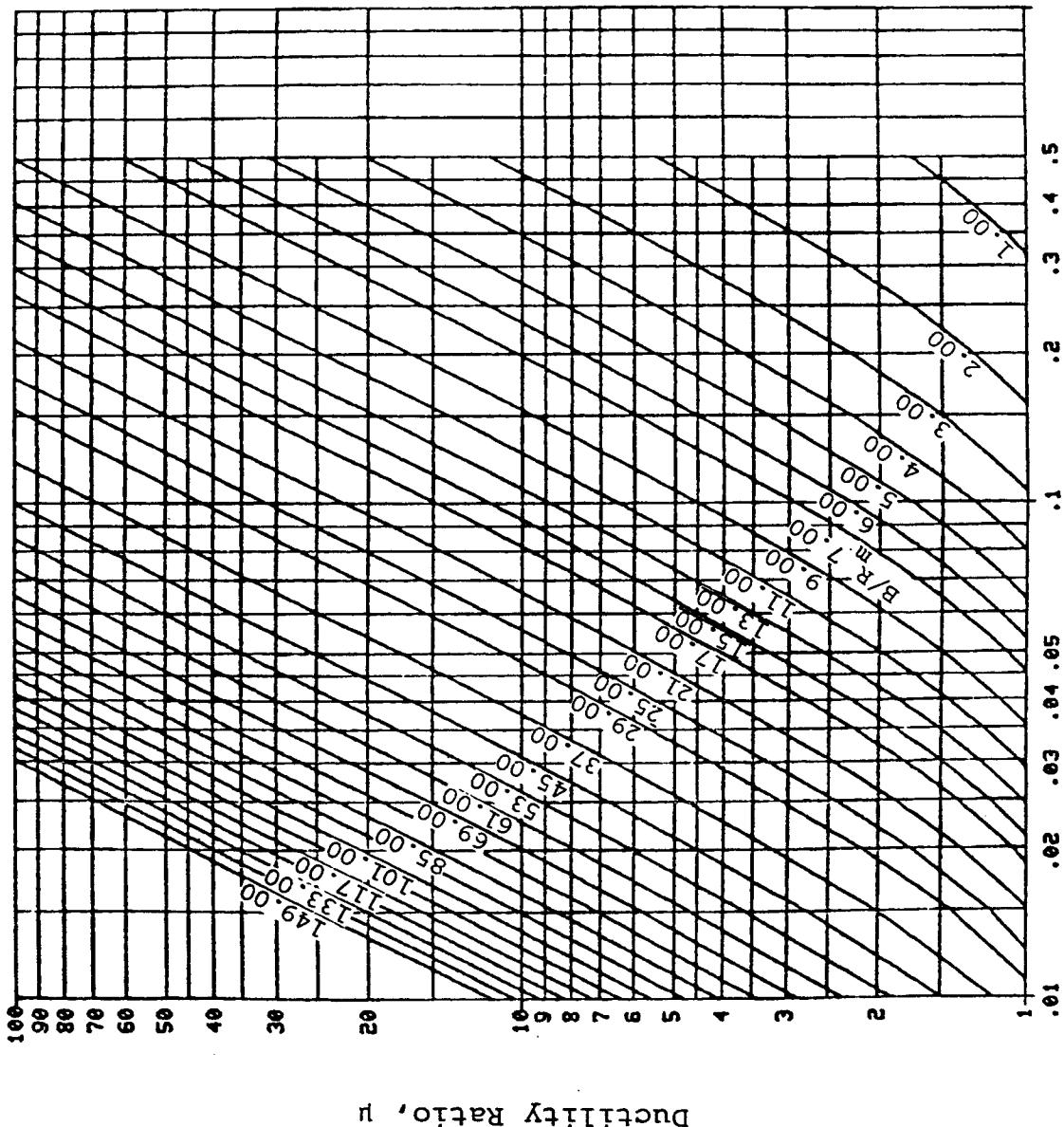


Figure B-41. Response Chart for $C_1 = 1.00$ and $C_2 = 0.00$